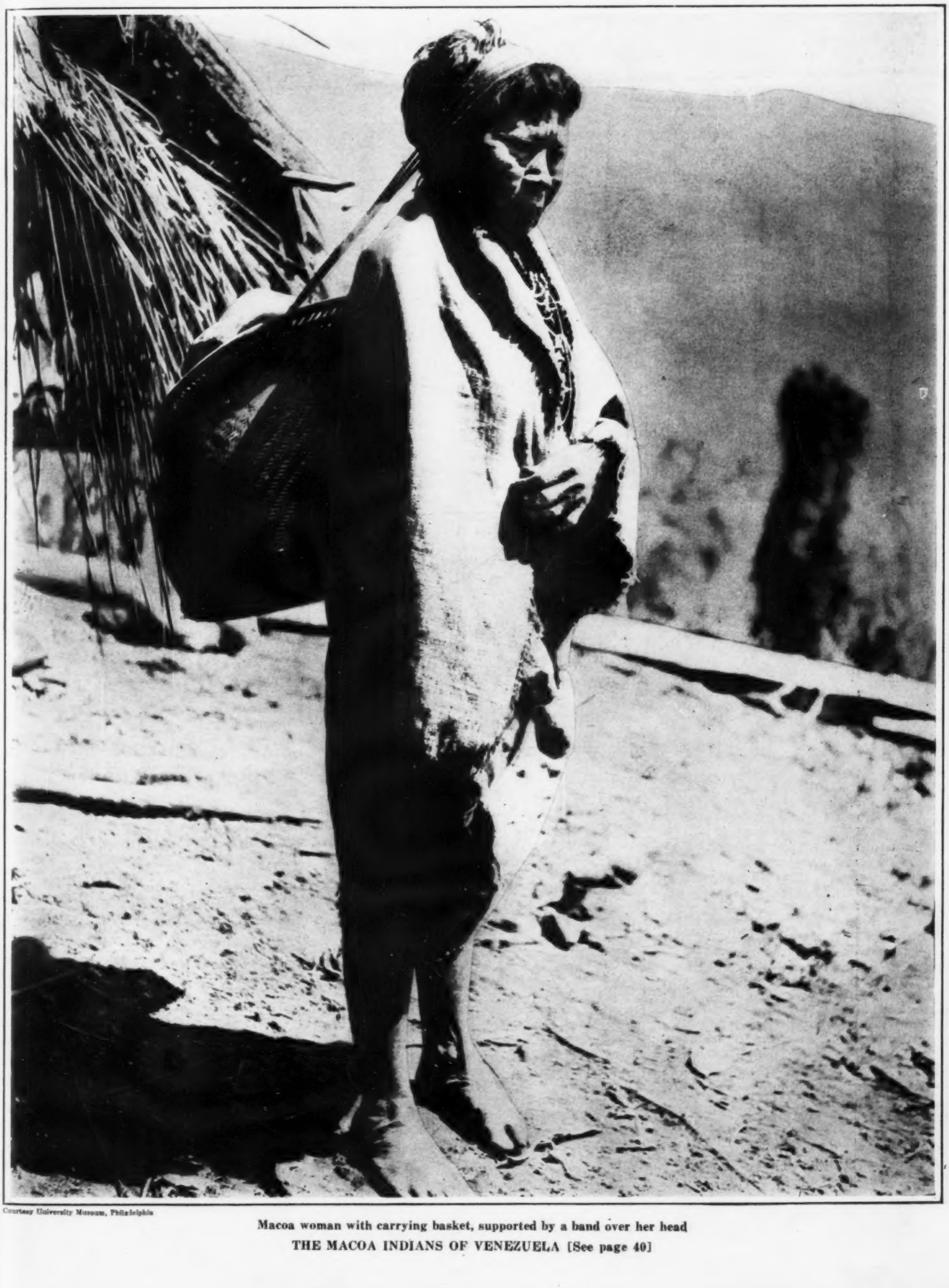
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXXVII NUMBER 2246

NEW YORK, JANUARY 18, 1919

Published weekly. Entered as second class matter, December 15, 1887, at the Post Office at New York, N. Y., under Act of March 3, 1879

10 CENTS A COPY $5.00 A YEAR



Courtesy University Museum, Philadelphia

Macoa woman with carrying basket, supported by a band over her head

THE MACOA INDIANS OF VENEZUELA [See page 40]

The Age of the Earth*

A Discussion of Recent Evidence from Geology and Astronomy

By Harlow Shapley, at Wilson Solar Observatory

"NATURE vibrates with rhythms, climatic and diastrophic, those finding stratigraphic expression ranging in period from the rapid oscillation of surface waters, recorded in ripple-mark, to those long-deferred stirrings of the deep imprisoned titans which have divided earth history into periods and eras. The flight of time is measured by the weaving of composite rhythms—day and night, calm and storm, summer and winter, birth and death—such as these are sensed in the brief life of man. But the career of the Earth recedes into a remoteness against which these lesser cycles are as unavailing for the measurement of that abyss of time as would be for human history the beating of an insect's wing. We must seek out, then, the nature of those longer rhythms whose very existence was unknown until man by the light of science sought to understand the Earth. The larger of these must be measured in terms of the smaller, and the smaller must be measured in terms of years. Sedimentation is controlled by them, and the stratigraphic series constitutes a record, written on tablets of stone, of these lesser and greater waves which have pulsed through geologic time."[1]

The measurement of geologic time is of much importance outside of the realms of geology and biology. Closely related to the history of sedimentary rocks are the age of the Earth as an astronomical body and the evolution of the planetary system. We shall see from the discussion of the following pages that the nature and speed of stellar development are also involved in this problem, and even the fundamental physical problem of the source of the radiant energy of stars. Thus the recent important studies of the age of the habitable Earth by geologists and paleontologists—Holmes, Schuchert, Matthews, Barrell, and others—have high significance in general problems of cosmogony. The progress of science frequently demands and utilizes close co-operation of its many branches. We may study the stars, indeed, with the aid of fossils in terrestrial rocks, and acquire knowledge of atomic structure from the climates of Precambrian times.

I have begun this paper with the introductory paragraph of a remarkably comprehensive and important memoir on the duration of geologic time by Professor Joseph Barrell of Yale University. In the growth of our concepts of the age of the Earth, his discussion is likely to mark an epoch because of its consistent carefulness, its great expansion of geologic time beyond the commonly accepted limits, and its decided rebellion against the stringent limitations set by Kelvin and later physicists. Excepting a few others, such as Arthur Holmes[2] of England, geologists have heretofore hesitated to correlate directly the radioactive evidence of the age of rocks with the records of stratigraphy.

THE TIME SCALE IN THE HISTORY OF THE EARTH.

Before reviewing some of the more salient points in Barrell's revision of geologic time, a chronological table of earth history may be given, incorporating his final estimates. I have adapted the tabular data from numerous sources[3]. The scheme of eras and periods follows traditional lines rather than the more logical arrangement of eras based upon organic evolution and of periods based upon modern views of the relative importance of the major disturbances that punctuate geologic history. It should be noted that the birth of the various mountain systems usually extended over more than a single period; the time indicated in the last column is that of greatest activity or of maximum uplift.

Numbers of the third and fourth columns, referring to the total time elapsed since the beginning of the corresponding period, are taken from Barrell's memoir. He states that the column designating the minimum values is "regarded as the more probable, but it is desirable to give maximum and minimum estimates in order to prevent a single column of figures conveying the idea of a precision or certainty which is not yet attained." The divergence of the two columns shows the order of uncertainty given to the results by the summation of the estimated probable errors of all the various factors which enter the determination of the relative and absolute ages.

Some of the points in geologic history are determined with much greater accuracy than others; the beginning of the Cambrian is far from certain, while the age of Devonian and Carboniferous rocks is fairly definite. The numbers for Precambrian times, which I have added parenthetically to the table, are just short of being hypothetical, in that a considerable uncertainty arises in estimating the actual beginning of a division. The ages of some of the rocks of these periods are accurately known; but the precise geologic positions within the periods are in general not as yet determined. Barrell remarks (p. 752) that "surprising as it may seem, the date known with the greatest precision lies far back in Precambrian time. From Norway, Texas, Quebec, and German East Africa uranium minerals associated with granites give an age which approximates 1,120,000,000 years." The great masses of Precambrian rocks have long been held to represent at least as great an interval of time as the whole of subsequent history. It now appears that the oldest known rocks, the granite-gneisses of the Laurentian system in Canada for example, were in existence nearly a billion and a half years ago.

ERA	PERIOD	TIME SCALE IN MILLIONS OF YEARS		CHRONOLOGICAL NOTES
		MINIMUM	MAXIMUM	
Psychozoic (Age of mental life)	1. Recent	1	1.5	Dominance of man
	2. Pleistocene			Periodic glaciation; primitive man
Cenozoic (Age of mammals and modern floras)	1. Pliocene	7	9	Himalayas; man-apes
	2. Miocene	19	23	Modern Alps; three-toed horses
	3. Oligocene	35	39	Pyrenees; Apennines
	4. Eocene	55	65	Mt. Wilson[1]; modern mammals; four-toed horses
	5. Paleocene			Primitive mammals; five-toed horses?
Mesozoic (Age of reptiles)	1. Cretaceous	95	115	Andes; Rocky Mountains
	2. Commanchian	120	150	Rise of flowering plants
	3. Jurassic	155	195	Sierra Nevada; flying reptiles; first birds
	4. Triassic	190	240	Rise of dinosaurs
Paleozoic (Age of amphibians, fishes, and higher invertebrates)	1. Permian	215	280	Appalachians; Ural Mountains
	2. Pennsylvanian	250	330	Paleozoic Alps; primitive insects
	3. Mississippian	300	370	Early Coal Measures
	4. Devonian	350	420	Earliest known land floras
	5. Silurian	390	460	Age of fishes
	6. Ordovician	480	590	Rise of invertebrates
	7. Cambrian	550	700	Dominance of trilobites
Proterozoic	1. Late	(1000)		Oldest known fossils
	2. Early	(1200)		Primitive marine invertebrates
Archeozoic	Paleo-Laurentian, etc.	(1500)		Unicellular life?
Primordial				
Cosmologic		(3000?)		Origin of Earth

[1]Arnold and Strong, Some Crystalline Rocks of the San Gabriel Mountains, California, *Bulletin of the Geological Society of America* 16, 183, 1905; Suess, The Face of the Earth, vol. 4. (Oxford), 1909, p. 425.

"Beyond these most ancient milestones lies the Primordial era, whose stratigraphic record has been destroyed by engulfment in magmas from below and by repeated cycles of erosion from above. As to its length, there is no indication other than that the oldest known rocks which mark the beginning of the following era contain sediments testifying to an earth surface on which air and water played their parts, much as in later times. Crust, ocean, and atmosphere had by the opening of the Archeozoic already attained a condition of stability."[4]

The last entry in the table, that for the origin of the Earth is certainly hypothetical, but it is of interest as an independent determination that is not out of harmony with geologic evidence. It is given by Jeffreys[5] as a rough theoretical value of the age of the planetary system, being derived, on the basis of the tidal evolution theory, from a consideration of the present orbital elements.

RHYTHMS AND THE MEASUREMENT OF GEOLOGIC TIME.

Professor Barrell's discussion is primarily an analysis of geologic evidence, considering especially the influences of "the fundamental factor of composite rhythms." It is in the recognition of these age-long action and the accumulation of solutes in the sea, the rhythms—the pulsatory deviations from strict uniformity in all geologic processes—that he reaches conclusions differing widely from the usual results. Chamberlin, Holmes, Schuchert, and a few others also recognize that the average rate of erosion, sedimentation, and crustal movement in the remote past cannot be closely equated with the rates in recent and present times. We now live in an epoch of great continental uplift and all processes are conspicuously accelerated. Chamberlin writes:[6]

"Because of the relatively high gradients, the wash of elastic material from the slopes and its deposition in the basins, as well as the transfer of salts to the sea, are today more rapid than in average times. We seem to be at, or near, one of the great extremes of intensification of the processes of solution and degradation. And so, whether conclusions are based upon degradation and elastic deposition, or upon solvent action and the accumulation of solutes in the sea, the present rates are high rates."

Admitting the present high rates of denudation and deposition and their irregularly rhythmic nature, with the resulting breaks in the sedimentary records, Barrell concludes that a fair interpretation of present stratigraphic evidence demands a duration of time perhaps ten or fifteen times longer than that required by a strict uniformitarian treatment.

The hypothesis of compound rhythms is applied by Barrell to all phases of geologic action. Some oscillations are extremely short and indefinite, others are long and more surely recorded in the rocks. The compounding and balancing of the effects of various pulsations give rise to crescendoes and diminuendoes in the resultant flow of geologic events. The sharp oscillations of decades, centuries, and thousands of years may be classed as solar climatic rhythms; the long, slow, and massive movements as diastrophic climatic changes. A cycle of some forty million years appears to mark the crustal and climatic disturbances which terminate the periods; possibly a cycle of two hundred million years separates the eras, if a proposed delimitation of the greater divisions be accepted. The present great continental elevation was matched in the Proterozoic, indicating the most far-reaching rhythm of all geologic time. This doctrine of rhythms is taken by Professor Barrell even to the utmost limits of cosmogony when he subscribes to the argument that "the apparent running down of the visible universe must be but one phase of a recurrent cosmic cycle philosophically necessary in infinite time, or else the running down would have been completed in previous enternity" (p. 904).

Before Barrell's work the principal geologic methods of measuring time were based upon: (*a*) erosion and sedimentation, (*b*) chemical denudation and the sodium in the sea, (*c*) the thermal gradient of the crust. He has carefully examined the postulates underlying these methods, which have generally given estimates of time very much smaller than those given by considerations of rhythms in the sedimentary series and by the measurements based on radioactive processes. Thus the viewpoint of his treatment is strictly geologic, but a full review of the evidence furnished by radioactivity is included, derived mainly from the publications of Holmes and the experimental work of Boltwood and Strutt.

The new scale of geologic time is constructed, therefore, by the dovetailing of two lines of evidence[7]:

*Publications of the Astronomical Society of the Pacific, No. 177.

[1]Barrell, Rhythms and the Measurements of Geologic Time, *Bulletin of the Geological Society of America*, 28, 745-904, 1917.

[2]The Age of the Earth (London), 1913.

[3]They include: Barrell, *op. cit.*; James Geikie, Mountains, their Origin, Growth, and Decay (Edinburgh), 1913; Huntington, The Climatic Factor (Washington), 1914; Matthews, Climate and Evolution, *Annals of the New York Academy of Sciences*, 24, 171-318, 1915; and the geologic manuals of Pirsson and Schuchert, Chamberlin and Salisbury, and Scott.

[4]Barrell, p. 881.

[5]*Monthly Notices*, 78, 424. 1918.

[6]Quoted by Holmes from a private letter, *op. cit.*, p. 79.

[7]Large parts of the next five paragraphs are quoted, with small textual alterations, from various sections of Barrell's memoir.

First, the thickness and character of the sediments give stratigraphic ratios of the lengths of the several periods. The ratios are subject to considerable uncertainty; yet, when derived with a knowledge of the variables involved, they give some measure of the relative durations. Second, the quantities of helium and lead in radioactive minerals give minimum and maximum measurements of age. These ages are open to some uncertainty owing to the loss of helium or the presence of original lead, and the stratigraphic positions of the rocks holding the minerals are also in most cases not closely known. Nevertheless, the radioactive minerals give measures of absolute age which are of the right order of magnitude and in proper sequence, as shown by the geologic data.

The adjustment of these two lines of evidence serves as the basis for a scale of geologic time expressed in years. The result is comparable to the first crude measurements of the distances of the stars in space. The progress of research will continually refine the determinations and lead to a higher order of precision; at present the important conclusion is that time, since the beginning of the Cambrian, is from ten to fifteen times longer than has been generally accepted by geologists.

RADIOACTIVITY AND THE AGE OF ROCKS.

The method of measuring the age of the rocks that include radioactive minerals is so generally known that little explanation need here be given. From the time radioactivity attains equilibrium in a thorium or uranium mineral, the end products accumulate within it at a uniform rate. These products are not removed from a dense crystalline rock unless the mineral is subjected to passing solvents, which would then surely record their effects by the alteration of the mineral itself. An atom of uranium (atomic weight 238) will ultimately give rise as stable products to eight atoms of helium (atomic weight 4) and one atom of isotopic lead (atomic weight 206). If the quantity of these can be measured and compared with the quantity of uranium in the same material, data are obtained for measuring the age of the mineral and with it the age of the rock-formation of which it is a part.

If a mineral contains a percentage, Pb, of accumulated lead of radioactive origin, and a percentage of uranium, U, then the age of the mineral is given by:

$$\text{Age} = \frac{\text{Pb}}{\text{U} + 0.575\ \text{Pb}} \times 7{,}500 \text{ million years}$$

The numerical values in this formula are based upon an unpublished discussion by Professor Boltwood, who considers that the half-value periods of radium and uranium are known within two per cent.

The rate of decay apparently is not affected by the nature of chemical combination or physical state. Laboratory experiments have duplicated the conditions that exist in the outer crust of the Earth. Temperatures ranging from that of liquid air up to 2,500° C., and pressures up to 160 tons per square inch have been found not to influence the rate of disintegration of the products of radium. It is highly probable but not as yet actually demonstrated that uranium is similarly unaffected. Thus the atoms of uranium break up with a uniform rate whether they are in elemental form or combined in a salt; whether they are in solid, liquid, or gas. Nothing is known to support a hypothesis that there is a change in stability of unstable atoms by a process of aging.

The possibility that uranium is affected by ranges of temperature and pressure that do not affect its less stable derivatives can be and, to some extent, has been tested by geologic evidence. Uranium minerals from the same well-established stratigraphic position, but in different localities, and, therefore, for millions of years under widely different physical conditions, yield accordant results for the age of the rock-formation. Another valuable test is that of proper sequence—invariably reliable analytical work shows that the older the rock-formation, the greater the lead and helium ratios. Believing he has found discordance in such cases, Becker is inclined to discount the whole radioactive method; but Barrell's critical examination of the same data shows that the errors in the adopted stratigraphic positions and in the use of the radioactive analyses wholly account for the supposed discrepancies.

The summation of all the evidence therefore makes clear that the properties of radioactive elements afford a remarkable and reliable means of dating the principal incidents in the ancient history of the Earth.

THE EARTH'S LOSS OF HEAT.

In the earlier history of speculations concerning geologic time, those students who were not too much hampered by conventional interpretations of the first chapter of Genesis felt no need of placing a limit to the age of the Earth. "No vestige of a beginning, no prospect of an end" is frequently quoted from Hutton. For the deposition of the known sediments according to uniformitarian principles, Lyell saw the necessity of hundreds of millions of years; and Darwin believed that the transformation of species and the high development of animal life required similar lapses of time.

In propounding the contraction theory of solar energy, Helmholtz in 1856 noted that the past history of the Sun would be limited to some twenty million years. A few years later Lord Kelvin attacked the problem from the standpoint of the flow of internal terrestrial heat, obtaining similar numerical results. Kelvin invaded the domain of geology (thus the geologists are wont to put it) hoping to reform its speculations and bring them into accordance with the doctrines of the conservation and degradation of energy. His mighty prestige and his unimpeachable mathematics silenced the protests of biologists and stratigraphers alike, and for several decades he and contemporary physicists allowed but ten or twenty million of years for the past duration of the habitable Earth.

It is a result of observation that at least near the surface of the Earth the temperature of the rocks increases on the average about 1° C. for every 100 feet in depth. This of course indicates that the Earth is losing heat, and, supposing an original temperature of the whole Earth equal to that of molten rock, the Fourier theory of heat conduction permits a calculation of the total duration of inhabitable surface temperatures. Such reasoning naturally assumes that the only source is the primal high temperature, and that the Earth is simply cooling off from its molten beginning. Hence, at some past time the surface was too hot for life and, at a future time, all depending on the observed temperature gradient, it will be too cold. That was all there was to the problem and its solution, according to the physical theory, and the recent imposing Ages of Ice were for a time considered as evidence of the approaching, inevitable and eternal frigidity.

The physical argument was adopted, in general, and attempts were made to compress the geologic record into a narrow interval of time; many geologists, however, would not accept the dictum. For instance, in 1892 Sir Archibald Geike[8] objected with the following somewhat prophetic statement:

"That there must be some flaw in the physical argument I can, for my own part, hardly doubt, though I do not pretend to be able to say where it is to be found. Some assumption, it seems to me, has been made, or some consideration has been left out of sight, which will eventually be seen to vitiate the conclusions, and which when duly taken into account will allow time enough for any reasonable interpretation of the geological record."

As a sort of a compromise between the inexorable physics and their own feelings as to the duration of geologic time, a value of a hundred million years came to be pretty generally accepted by geologists with no insistence on certainty, for the age of the oldest known sedimentary rocks.

Professor Harker[9] points out that Kelvin also had at one time an inkling of the true state of affairs; he recognized that, while the Earth is certainly losing heat, "it is possible that no cooling may result from this loss of heat, but only an exhaustion of potential energy, which in this case could scarcely be other than chemical affinity between substances forming part of the Earth's crust." This, however, Kelvin dismissed as "extremely improbable," and proceeded on the assumption that primal heat is the only form of energy to be reckoned with.

Kelvin's surmise as to potential energies and chemical affinities was an interesting prophecy; for, as we now know, the solution of the dilemma was the discovery, less than twenty years ago, of radioactivity in terrestrial rocks, which provides enormous stores of thermal energy. The discovery was, in fact, more than a solution; the percentage of radium in surface rocks is one hundred times too much to just counteract the observed loss of heat. The explanation of this condition must be that the radioactive minerals are confined to surface formations only, as otherwise the Earth would be heating up with "geologic rapidity." "The most probable depth of the radioactive layer may therefore be placed at 30 miles," Holmes concludes (p. 135), after considering other values, "and the basal temperature in this case would be about 750° C, which would be more in agreement with the requirements of volcanic action." This approximate result is independent of the observed temperature gradient, involving only the character of terrestrial rocks, "for there can be no doubt that the radium and thorium content decreases with depth for the same reason that the type of rock varies with depth. * * * There is a rough proportionality between the acidity or percentage of silica of a rock and its radium content. The more basic rocks are much poorer in radium, and as would be expected, in thorium also. Now we have good reason to suppose that the more deep-seated rocks of the Earth's crust are of basic and ultra-basic composition, and that below the 30-mile crustal zone they are exclusively ultra-basic, perhaps similar in composition to the material of stony meteorites. * * * Within the stony zone, which extends down several hundred miles, lies the heavy core of the Earth, probably of metallic composition, like the iron meteorites. If we may judge from the latter, this nucleus is entirely free from radium."[10]

With no prospect of ever knowing accurately the amount and distribution of radioactive elements in the Earth's crust, there is no longer any solid basis for calculating age from the temperature gradient of the Earth. The observed loss of heat is not an indication of previous thermal conditions. The Earth may be growing hotter; it may be cooling more rapidly than it would do if in radio-thermal equilibrium; or it may be in thermal equilibrium (the most probable condition, according to Holmes), gaining as much heat as it loses and eventually cooling only as the slow decay of the radio-elements permits.

We are thus justified, it appears, in believing in a greatly prolonged future for the inhabitants of the Earth. In terrestrial climates during geologic times we recognize no evidence of sensible secular change. Atmospheric temperatures are, of course, almost wholly dependent on the radiation of the Sun. The secular progression of solar energies, however, as we shall observe in following paragraphs, is apparently so small, when judged by our base line of a thousand million years, that we may consider the radiation as essentially constant. There is probably much better justification, therefore, in expecting the termination of terrestrial life in catastrophe, whether earthly or cosmic, rather than in climatic senility. To be sure, there is strong evidence that we now live in an interglacial epoch of the quickening ice pulsations of the Pleistocene, and we may indeed reasonably expect another advance of the oscillating ice sheets in the near (geologically-speaking) future; but in former times there have been equally extensive invasions of ice, followed by unknown millions of years of genial climates. In the past the fluctuations of land forms and of meteorological conditions have profoundly though slowly affected conditions for organic existence; but later than Proterozoic times there has been no complete interruption of plant and animal life, and as far as can be seen or intelligently predicted, the future, for similar ones, promises conditions no less favorable.

RADIOACTIVITY AND SOLAR RADIATION.

The discovery of radium rescued the problem of the age of the inhabitable Earth as far as its own interior cooling is concerned, from the narrow limitations set by the thermal gradient. But radioactivity will not suffice to account for the radiation of the Sun during geologic ages. We admit no potent source of energy back of terrestrial life other than solar radiation; and we have seen that, in supplying radiant energy at the required rate, the Helmholtzian contraction, which is the only very powerful origin of stellar energy now definitely recognized by astronomers, would suffice only for a few million years. Hence the geologic time scale is again embarrassed by physical theory. This circumstance, however, does not continue to divert faith from the testimony of the rocks, for, remembering the case of the thermal gradient, we look to a temporary ignorance of the properties of matter in accounting for this presumed discrepancy.

It is readily shown that the normal decomposition of known radioactive elements might be amply sufficient in the sun (as on the Earth's crust) to account for the *duration* of solar radiation; but in the case of the Sun this device is woefully deficient as to *amount*. If the Sun were composed entirely of uranium, in equilibrium with its disintegration products, the heat generated by known radioactivity would not be a third of the actual output. "The importance of radio-thermal phenomena is not felt until cooling has progressed to a more advanced stage, as exemplified by the Earth, when the heat lost is balanced against that set free by atomic disintegration."[11] Jeans considers that even all known electrical properties of matter, radioactive

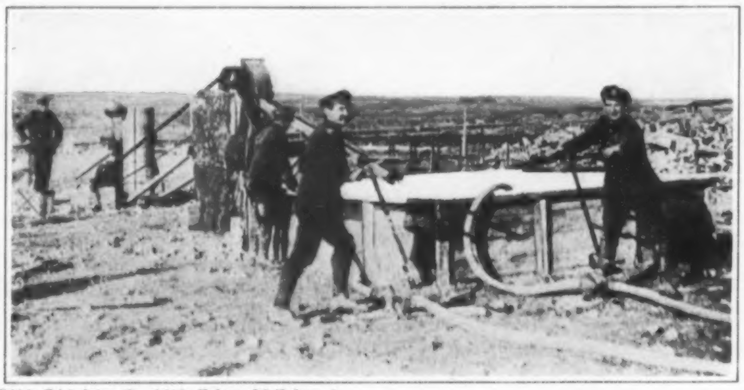
(*Concluded on page 42*)

[8] *Annual Report of the Smithsonian Institution for* 1892, p. 124.

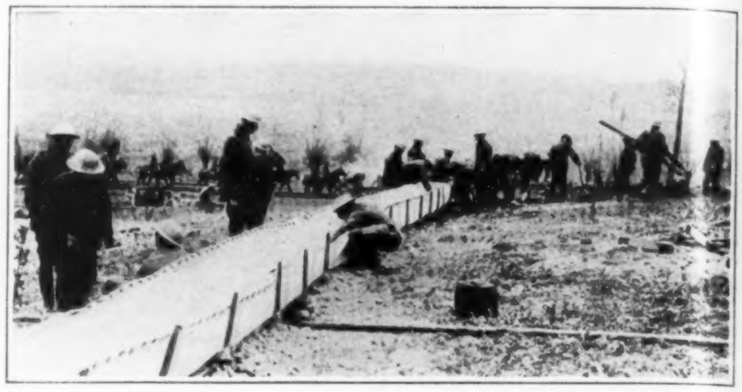
[9] *Nature*, 95, 107, 1915.

[10] *Op. cit.*, p. 138. Recent corroborative evidence of this viewpoint is afforded by studies of the radioactivity of Archeozoic rocks of southern India by Smeeth and Watson, *Philosophical Magazine*, 35, 206, 1918.

[11] Holmes, p. 117.



British official photos. Copyright by Underwood & Underwood
Pumping water from driven wells behind the British lines



Canvas water troughs for cavalry, used by the British

Water for an Army

Successful Hygienic Work of Great Importance

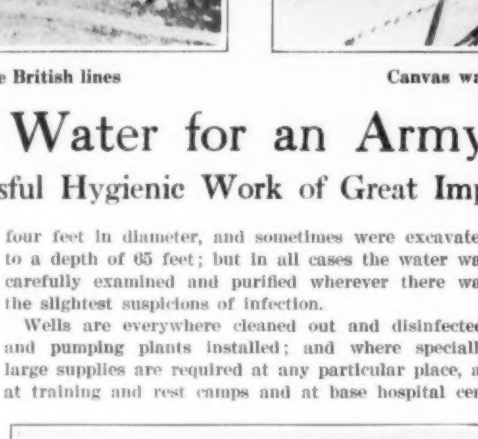
ONLY those who have actually been at the front during the late war will be able to fully appreciate the herculean task involved in maintaining the vast hosts of men there assembled in a manner to make their efforts effective. The largest department store in the world does not number among its multitudinous wares even a small portion of the materials that an army is constantly in need of, and as to quantities, these simply surpass imagination. This is not strange when we consider how lacking in experience the average man is when estimating numbers. If a crowd of five thousand people are assembled in one place, the ordinary observer would be likely to estimate the number at anything from twenty to fifty thousand, so that it is evident that when we deal with millions the task is absolutely beyond our comprehension, and a tabulation of the materials of every description needed by such a number of men, even for a single day, would seem to exhaust the capacity of the entire world.

If these armies were stationary at any one place the task of supplying them would be vast enough, but when they are constantly moving, and supplies must keep pace with them, the task becomes almost superhuman. The story of this work is too great ever to be assembled in a single narrative, but such of it as may reach us in even fragmentary form will constitute a record of wonders in engineering and executive accomplishment.

One of the simpler materials constantly required by an army, both for man and beast, is water, and this it is generally expected to be found on the spot. And although great quantities are needed, it would not ordinarily be so difficult, as compared with some other descriptions of supplies, to provide a sufficiency. The circumstances developed in France during the great struggle were, however, decidedly exceptional. On account of the crowding of great bodies of men into limited areas, where they carried on existance under primitive conditions, it was exceedingly difficult to prevent the contamination of streams and wells which would under ordinary circumstances be relied upon. Then again, the enormous pits excavated by the great, high explosive shells collected water that soon became stagnant, and contaminated the surrounding supplies; and to make matters still worse the Germans systematically poisoned and infected every source of water supply within their reach.

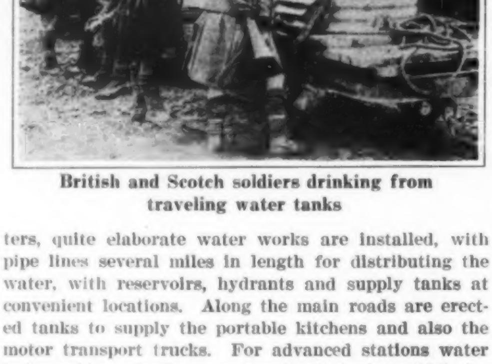
All of these things made the work of supplying potable water to the armies a difficult task, particularly as it was one that had to be kept up continuously without intermission, no matter how great or how rapid the changes in position might be. Chemists and bacteriologists were constantly busy examining and testing every possible source of water, and these tests had to be repeated day by day, and even several times a day to guard against infection. In many districts river water was used almost exclusively, as in the valley of the Somme; and in such cases the water was thoroughly sterilized and filtered before the troops were permitted to make use of it. On the rivers purifying plants were placed in barges, while in other regions portable sterilization apparatus was carried on railways and motor trucks, which moved from place to place as required. In considerable portions of the territory in which the British were operating, driven wells were extensively used, and these wells had to be put down from 150 to 200 feet to penetrate the underlying chalk formation and reach the water-collecting levels. In the Verdun region most of the water was obtained from wells dug by hand, although many driven wells were also sunk. The hand-dug wells were about four feet in diameter, and sometimes were excavated to a depth of 65 feet; but in all cases the water was carefully examined and purified wherever there was the slightest suspicions of infection.

Wells are everywhere cleaned out and disinfected, and pumping plants installed; and where specially large supplies are required at any particular place, as at training and rest camps and at base hospital cen-



British and Scotch soldiers drinking from traveling water tanks

ters, quite elaborate water works are installed, with pipe lines several miles in length for distributing the water, with reservoirs, hydrants and supply tanks at convenient locations. Along the main roads are erected tanks to supply the portable kitchens and also the motor transport trucks. For advanced stations water is brought up by large motor truck tanks, which deliver to tanks as near the front lines as possible.



Copyright, Underwood & Underwood
Motor truck water transports at an American camp

From these tanks water is taken into the trenches in small kegs. Watering animals presents a special problem, for where there are large numbers it is not possible to alow them to drink directly from a river as their tramping would soon muddy the stream for a long distance; so the water is pumped up into special tanks, from which it can be drawn into troughs as required. For pumping, every kind of apparatus is employed according to circumstances. Where small quantities are required a simple hand pump is all that is necessary; while for the larger establishments a regular steam plant is installed. Often for filling motor truck tanks a pump is carried in the truck, in which case it is operated by the power of the truck engine, and this makes a movable outfit of great convenience.

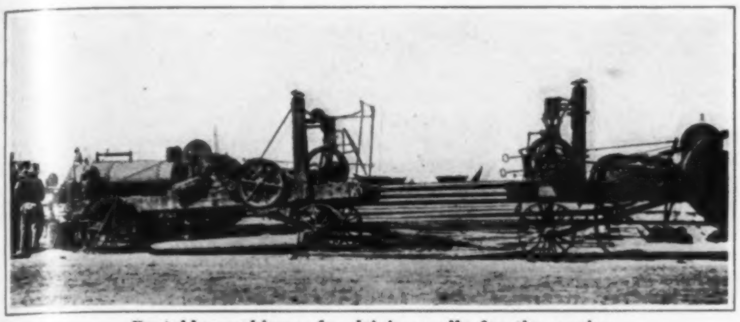
The importance of a supply of pure water may be appreciated if we look back over the records of hygiene in the armies of recent wars, and note the terrible losses resulting from enteric diseases, and compare them with the practical absence of this trouble in the present war where vastly greater numbers of men were concerned. Typhoid fever is always a much dreaded disease wherever great numbers of human beings are congregated together, and in every city it is one of the most difficult problems we have to contend with and which is ever present even under the most sanitary conditions it is possible to maintain; and when we consider the very small amount of the losses from this disease during the present war we can appreciate the wonderful work done by the medical departments of the armies and marvel at their success in maintaining healthful conditions under such adverse circumstances.

Rubber-Seed Oil

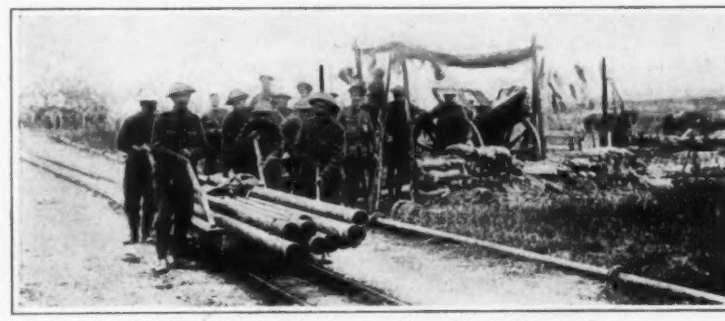
THE report of the Federated Malay States Agricultural Department shows evidence of the growing tendency to apply scientific methods to the rubber industry. A description is given of the method of manufacture of rubber-seed oil and its residual product with a view to putting it on a commercial basis. It would seem, from the report, that this high-grade oil requires hardly any refineing, is obtained from a waste product available in great quantity, easy to collect, transport and store and easy to crush. It would certainly pay in normal times to ship the seeds or kernels but, as the prospects of freight facilities for some years do not present a bright outlook, it would seem that shipping the oil is the better proposal. Oil keeps better than seeds and is more easily stored. Experiments with a consignment of 30 tons of seeds sent to England resulted in $250 per ton being obtained for the oil, while $40 per ton was realized for the residual cake. At the time linseed oil stood at $300 per ton. The difference of $50 per ton may be put down to the prejudice with which all new products have to contend. As far as can be foreseen, rubber-seed oil will occupy a place but little inferior to linseed oil as soon as the world's markets have acquired confidence in the new product. Finally, the production of rubber-seed oil would not interfere with the market for coconut oil or sesame, as these oils are used essentially as human foods in the form of margarine and cooking fats. These oils are never used (as rubber-seed oil is likely to be) for paints, varnishes, red and white lead, packing compositions for joints, soft soap manufacture and the like.—*Jour. Ind. and Eng. Chem.*

Electrical Meter Testing in Germany

NEW regulations have been issued by the Physikalisch-Technische Reichsanstalt (*Elektrotechnische Zeitschrift*, July 4th), regarding the testing of electrical meters. The complete outfit consists of transformers and one or more meters. During the testing of the instruments all auxiliary apparatus (power, current, voltage indicators, relays, etc.), that are to be actuated by the transformer in practice must be connected up or replaced by substitute resistances and coils with the correct energy consumption and power factor. If the secondary leads of a current transformer exceed 0.15 ohm, an equivalent resistance must be inserted during test.—*Nature.*



Portable machinery for driving wells for the armies



British soldiers bringing up pipes for water supply

Wonderful Exhibition of Old French Silks

Glories of Color Revealed in Ancient Fabrics, Product of the Lost Art of Exiled Huguenots

What is perhaps the most wonderful exhibition of old French Silks in the world is to be seen in the library of the International Buyers' Club at 130 West 42nd Street, New York. The collection comprises more than 700 specimens of silk manufactured by the descendants of the Hugenots who settled in Spitalfields and Bethnal Green, London, after the revolution of the Edict of Nantes in 1685. An incorporation of silk workers had been formed at Spitalfields as early as 1629. When the Edict of Nantes, fifty-six years later, dispersed to Switzerland, Germany and England, a vast body of the most skilled artisans in France, the bulk of the French Protestant weavers joined their English fellow craftsmen at Spitalfields, bringing with them the undisclosed secrets of their art which they prosecuted in the land of their exile. As the Huguenots were devout church goers, it remained for the pastor of the French Protestant Church of London, established by Royal Charter of Edward VI, in 1550, to assemble a collection of the most exquisite specimens of the work of his parishioners which had been attained by processes and formulas of weaving and dying, most of which today rank among the lost arts. The collection was amplified and treasured by subsequent ministers of the gospel. Eventually it came into the hands of the Rev. G. G. Dougars, pastor of the church by whom it was exhibited at the Paris Universal Exposition in 1867. It has lately come into possession of the International Buyers' Club and is said to be the most valuable of its kind in the world.

The fabrics of the collection are as durable and the colors as brilliant as if they were turned from the looms yesterday. The disintegration of the silk fabric that one sometimes sees in Chinese Mandarin coats has not taken place. Indeed the old French silk workers did not develop their art from the ancient Chinese who jealously guarded the secrets of their craft. The silk industry was originated in the western world by two Persian monks who had resided in China and who in about 550 brought to Constantinople the eggs of the silk worm in a hollow bamboo tube. From these contents developed the silk industry of Europe. Under Justinian a monopoly of the silk trade and manufacture was reserved to the Emperor and looms worked by women were set up within the Imperial palace at Constantinople. The Saracenic patterns and colors became famous. The nurture of the silk worm and manufacture of the silk were introduced into Greece where they took kindly to their new home. Thence they spread to Sicily; thence to southern Italy. In the first half of the 12th century the Bishop of St. Evroul, brought with him from Apulia, in southern Italy, several large pieces of silk, out of the finest of which capes were made for the Cathedral chanters. In 1480 silk weaving was begun under Louis XI at Tours, France, recently an important headquarters for the American Army and Aviation section in France. In 1520 Francis I brought from Milan silk worm eggs which were reared in the Rhone Valley. Thus the French silk manufacture had as its base, though somewhat remote, the famous silken textures of Byzantium. In any event, many of the Saracenic patterns are to be noted in the present collection, which reveals the brilliance of the oriental artistry but not its garishness. Moreover, there is an elusive delicacy about the French silks that quite defies description.

Many of the French patterns are quite up-to-date and are said to be in line for any revival of styles. This is particularly true of the tiny patterns in checks, blue, red, green and brown in fields of white silk, all of which are adapted to cravats. The most gorgeous colors are shown in the silks for upholsteries; the most delicate and evanescent in those evidently intended for women's apparel or draperies. Wonderful dyes the French weavers used, vegetable dyes that increase in their beauty as the years go by. Gold, pure, yellow, brilliant gold is shown; white, ivory, flesh, coral, turquoise, apricot, ocean-green, ashes of rose, chartreuse, honey, maple, geranium, scarlet, cardinal, dark cardinal, garnet, and a thousand other tints that would be hard to match today even when we have 323 shades of navy blue alone.

One of the most exquisite samples is of beautiful ribbon of satin and silk combined, the pale, yellow gold satin going through the crisp black field of silk. At first glance the sample suggests tortoise shell or the beautiful gold and jet black Philippine hard wood known as camagon which sells among the cabinet makers of Canton for its weight in silver. The back ground silk fabric is rough and corded, of a rich dead black, made by the "beetle process." As the eye of the observer moves a fraction of space from its position, the light catches upon it and it becomes a glistening black sheen, iridescent, shifting and changing with light as though it possessed the quality of an opal. Another design shows a field of pale gray silk interlaid by a deeper stripe of gray through which runs a design of pale gray blue. In upholsteries the beautiful colors and designs outrival the most gorgeous mandarin coats of China. One of these shows a field of black silk interwoven by arrows of purple and silver, purple and gold, brown and silver, blue and gold, pink and silver, by a different shade of silver and black, by magenta and silver, and green and gold. The design suggests a scattering of jewels, pearls, sapphires, jade, onyx, gold and silver upon a burnished slab of ebony. All the glories of color, of brilliant, flashing color, of gorgeous, riotous color, are told in silk. The French weavers, too, achieved great delicacy in working in their pale shades. A sample shows white silk with still whiter flowers, patterns with the faint gossamer shimmer of the inside of a shell of pearl. Morning glories in very light gray and silver are shown upon a broad field of gray silk, the delicate tendrils, leaves and flowers revealing a delicate evanescent artistic quality, an intangible conception that cannot more be described than the pearly beauty of a white lily. These designs were most popular with the ladies of the court at the time of Margaret of Navarre who constituted herself a special patroness of the Huguenot silk workers. The fleur de lis is frequently in evidence in the patterns, one of which shows the design worked on a field of gray in blue, and gold, and silver.

The oriental influence is shown in the rich borders for tapestries on fields of black Ottoman and black armazine, which present the aspect of an inlaid mosaic of jewels, flashing colors on which the light seems to play and shift. Another sample in gold, black, and red suggests an old Aztec or Egyptian design.

The strength and durability of the silks in this collection, some of which are hundreds of years old, suggest that with reasonable care they are proof against disintegration of the ages. There is not a cracked, worn, or thin sample among them. The brilliance of their dyes, some of whose formulas are at present lost to the world, is evidence that the world may never be forced to be completely dependant upon any one nation for its dyes and that the forgotten lore in the art of dying fabrics reveals the varied future that may be revived under the spur of necessity. It is no later than August 15, 1918, that the "Deutsche Wirtschaftszeitung" stated that upon the resumption of peace the world would still be dependent upon Germany for its coal for dyes and that French coal did not afford the proper base for their manufacture. But the ceding of territory has altered the hypothesis on which the statement was based, and in the restoration of the arts of the past there will be many sources upon which to rely.

It is, of course, impossible to convey a full description of the silks in this collection without the use of color plates. Readers who happen to be in New York City, however, can view the collection itself on exhibition in the library of the International Buyers' Club on the second floor of the Bush Terminal Sales Building, 130 West 42nd Street, New York.

German Commercial Trickery

It is well known that many thousands of patents for chemical processes are held by German companies, upon which they have for years relied to maintain their monopoly of the chemical trade of the world; and since the war began it has also been learned that a large percentage of these patents are entirely fraudulent, inasmuch as they contain deliberate misstatements as to the working of the processes they purport to describe, and as to the materials employed. All of this was for the purpose of misleading those who attempted to work the processes, and of course renders these patents invalid. But in some cases the patentees were not content merely to mislead, but with that perverted ingenuity that has been so much in evidence in the horrors these people have introduced into war, and their methods of conducting it, have literally "mined" their patents by describing processes which, if followed, would be pretty certain to result in the death of the investigator.

When a people will resort to such practices as these in times of peace, and in their every-day dealings with their neighbors, what will they not do now that the hands of the world are against them? And yet there are those who assert that we were not at war with the German people, but only with the military clique!

Growth in Grey Cast Iron

Something more than a year ago Mr. J. E. Hurst put forward a theory that the chief thing is the removal of the free graphite from the exterior surface layers of the cast iron, and he has now elaborated it after an exhaustive set of experiments. The author suggests that the possible methods by which graphite might be removed without the subsequent production of cavities in the metal are briefly summarized below: (1) Superficial decarburization and the oxidation of the graphite followed by the liquation of the phosphide eutectic into the remaining cavities. (2) At temperatures of over 900 deg. Cent. within the range of temperature to which the above-mentioned samples have been exposed (900 deg. Cent. to 1,000 deg. Cent.) it is certain that a considerable portion of the graphite is redissolved, forming the austenite solid solution. He adds: "In those irons containing considerable quantities of phosphorus the conditions are considerably more complex, but there is every probability of the resolution of the graphite taking place with the production of complex ternary constituents. Under these circumstances the possibility of the removal of the graphite with the entire absence of holes will be appreciated."

Mr. Hurst rightly holds that the production of a decarbonized case around cast iron articles will prove of considerable service in the prevention of growth under many circumstances. It has already been suggested that this method should find application in the protection from growth of dies and permanent molds for iron and non-ferrous metals. Further experimental work will be necessary to determine the conditions under which this graphite can best be removed. The author has several permanent molds which have been protected in this manner by annealing at a temperature of 900 deg. Cent. to 950 deg. Cent. in ordinary brown rust (oxide of iron) for a period of 72 hours. The results have also been considerably improved by raising the annealing temperature of 975 deg. Cent. to 1,000 deg. Cent. Troubles, however, have been experienced in these cases through distortion. At this high temperature) from the preliminary investigations already made) the removal of the graphite would appear to be brought about through the formation of the ternary eutectic of iron, phorphorus, and carbon.—*The Practical Engineer.*

Plant Growth and Reproduction

It is well known that in many plants there is a well-marked antagonism between growth and reproduction. This is clearly seen in the case of many fruit trees where the conditions which lead to active vegetative growth may be inimical to the reproductive processes. In such cases the reduction of vegetative growth, as by root pruning, may bring about vigorous flower and fruit production. The study of the effect of external conditions on these two processes, growth and reproduction, is obviously of great importance. In the case of the higher plants, however, the difficulty of investigating such a problem is increased by the close connection under ordinary conditions of the various external factors; it is thus very difficult to alter one factor without altering others at the same time. In the case of algæ and fungi, which can be grown in the laboratory under artificial conditions that can be easily varied at will, the difficulties are not so great, and it is not surprising that in this field of work our knowledge is mostly based on experiments with the lower organisms. The art of growing micro-organisms, such as bacteria, fungi and also algæ, in pure culture has been carried to a high pitch of perfection, but since the growth of bacteria and fungi takes place within such wide limits and under a wide range of conditions, the analytic study of environmental factors has been largely neglected in the development of pure-culture methods. Some bacterial parasites of animals are markedly sensitive to temperature conditions, but the majority of fungi will grow within a wide range of temperature so the effect of temperature on the growth of fungi has not been fully studied. Again it is convenient in culture-work to grow fungi in tubes plugged with cotton-wool, *i. e.*, under conditions in which gaseous exchange must be reduced to a low level. Yet, since most fungi tolerate readily such conditions, the effect of aeration on the growth of fungi has been neglected. A certain amount of analytic work with the help of synthetic media was carried out by earlier workers, such as Pasteur and Raulin, and later by Winogradsky and Beijerinck. In 1896 Klebs published the first of his series of papers on the effect of external conditions on algæ and fungi grown in pure culture. Klebs did not confine himself to the effect of such conditions on growth, but he studied the effect of external conditions on reproduction also. Klebs put forward the view that growth and reproduction are processes which depend upon different conditions, and that as long as the conditions favourable for growth are present, reproduction in the lower organisms does not occur. Klebs brought out also a point of great importance, that the conditions suitable for reproduction are more restricted than those for growth, so that reproduction is liable to be inhibited by too high or too low intensity of some factor.

It is well known to mycologists and plant pathologists that though there is little difficulty in growing most fungi in pure culture, the production of reproductive organs by fungi under these conditions is quite another matter. Anything which will enable one to control the reproductive processes of such fungi is thus not only of great physiological interest, but of considerable practical importance in plant pathology. Reference may thus be made in this article to a valuable paper—not of most recent date, but very generally overlooked—by G. H. Coons on the factors involved in the growth and pycnidium formation of *Plenodomus fuscomaculans* (*Journ. Agric. Research*, v. 713-769, 1916), in which the relation of growth and reproduction to external conditions is very carefully studied. The fungus in question is one of the Sphæropsidaceæ and is parasitic on the apple.

It was found that in agreement with the dictum of Klebs there was a wider range of conditions suitable for growth than for reproduction. A small amount of growth will take place in conductivity water (sp. cond. 2×10^{-6}) in vessels of resistance glass. Such a growth is certainly very surprising. The number of spores used for inoculation was not more than fifty, so the growth observed could not be explained by transference of organic material from the spores. The salts required for development under these conditions, and in ordinary distilled water, were no doubt obtained from the glass, but the source of nitrogen, and especially of carbon is obscure; there is the possibility, first suggested by Elfving, that volatile substances may be absorbed from the laboratory air. It is interesting to note that while in conductivity water there was a just perceptible growth, in ordinary distilled water the growth was not only better, but a few pycnidia were actually produced. Under the conditions of the experiment conductivity water is the lower limit for growth, but "distilled water" the limit for reproduction. As Coons points out, the sensitiveness to extremely small quantities of salts renders the problem of determining the necessary elements for this fungus almost insoluble with our present technique.

Up to a certain limit, possibly up to M/50, increase in concentration of the food supply increases reproduction; after that point increase of food supply retards and finally inhibits reproduction. The organism was found to be sensitive to the reaction of the medium, and the different effect of different media was largely due to the reaction of medium not only at the start, but in later stages of growth. Many media, while having a favorable reaction at start, showed an unfavorable reaction later, with corresponding checking of growth. It was found that while growth can take place between the acid and alkali limits of + 30 and — 10 to phenolpthalein, yet reproduction is stopped by a reaction only slightly on the acid side of neutrality. Maize broth is a much better substratum than oat broth, but if the latter be acidified with an acid phosphate, or even hydrochloric acid, it becomes almost as good a medium as maize. The various laboratory media are rightly condemned as "rather purposeless, clumsy devices in which this organism is overfed." Progress can only be made by the use of synthetic media, and a large number of experiments were made with a medium containing in various proportions potassium dihydrogen phosphate, magnesium sulphate, maltose and asparagin. A solution containing these four substances in concentrations of M/100, M/500, M/100, M/500, respectively, was found to be an almost ideal culture medium for the growth and reproduction of this fungus; the pycnidium production was far higher than in any other medium. In this synthetic medium the inhibition of reproduction as a result of increasing or decreasing the carbohydrate or asparagin was very marked.

Light was found to be essential for reproduction, though not for growth. The light need not be continuous, for a short exposure to strong diffuse light of cultures which are ready to produce pycnidia will allow, for a time, the production of these bodies in the dark. Abundant aeration was found to be essential, while transpiration was found to be a factor of only secondary importance.

The extremely interesting and important observation was made that *the stimulus of light could be replaced by a few drops of hydrogen peroxide*. This observation was extended, and it was shown that a number of other oxidising agents, such as nitric acid, potassium permanganate, ferric chloride, would produce the same effect and cause the production of pycnidia in the dark. The view is put forward that among the parts of an organism there exists a strong competition for oxygen, and that under conditions which favor growth the available oxygen is all used for ordinary metabolic processes. If the food supply is reduced, as by transfer to media of lower concentrations or to distilled water, a "hunger-state" sets in and ordinary respiration is lowered. If the organism is now stimulated by light or by some oxidising agent, oxidation of the richer cell materials, such as fat and protein, sets in, and a large amount of energy is set free. "This energy is used in reshaping the reserve stuffs into complex protein bodies, the spores."—By Prof. V. H. Blackman, Sc.D., F.R.S., Imperial College of Science and Technology, London. (Plant Physiology Committee), in *Science Progress.*

Atlantic Flight

A Matter of Mathematical Analysis

By M. A. S. Riach

While a great deal is being written at present on the subject of crossing the Atlantic by aeroplane, by writers who for the most part are only superficially acquainted with the essentials of the problem, the possibility of constructing an aeroplane that shall be capable of making the journey in a single flight is one that is engaging the serious attention of aeroplane designers all over the country. The following brief analysis is intended to indicate the lines upon which the problem, in all probability, will be eventually solved, for undoubtedly it will be solved sooner or later.

The first question that naturally arises is that of size. Is it more economical to employ the small, heavily loaded, fast type of aeroplane that shall do the trip in, say, 14 to 16 hours, or, on the other hand, will the large and slow machine of big weight-carrying capacity eventually be the type adopted? In order to be able to form some idea of the relative merits of these two extremes, it is necessary to consider in some detail how the total load carried by an aeroplane is made up. This load may be split up, with sufficient accuracy for the purpose of mathematical analysis, into the following weights:

(1) The power plant weight, comprising the motors, airscrews, radiators, and water.

(2) The fuel weight, comprising petrol, oil, and tanks.

(3) The weight of the crew, pilots, and passengers.

(4) The weight of the aeroplane itself, which is to carry the whole of the weights summarized, including its own weight.

Now it is obvious that what is required is some formula which shall express the total distance capable of being flown in a single flight, in terms of the total weight of the aeroplane at the beginning of its flight and any other quantities which are independent of this initial load. Having found such a relation, it is a comparatively simple matter to see for what value of the initial load, &c., the distance capable of being covered is a maximum. In other words, it is possible to solve the problem of size—*i. e.*, whether to employ the small and fast or the slow and large type of aeroplane for the journey. Mathematically, we are not so much concerned with flying a particular distance, such as the Atlantic, as in obtaining the maximum distance it is possible to cover on any type of aeroplane in a single flight. The problem is complicated further, owing to the fact that the aeroplane is losing weight in fuel during its flight, and that the motors are probably being run throttled down, to some extent, for the greater part of the journey.

Analysing in detail the component weights of the complete aeroplane already mentioned, we find that there will be a sufficient degree of accuracy in making the following assumptions:

(1) The power plant weight varies as the horse-power developed by the motors.

(2) The fuel weight varies as the product of the horse-power of the motors and the time of flight, with a correction for the height at which the aeroplane is flying.

(3) The weight of the crew remains constant during the flight.

(4) The weight of the machine itself varies as the total weight at start of flight.

In this way it is possible to obtain a relation between the total weight at any time during the flight, and the total weight at start of flight, the horse-power of the motors, and the time. This may be called the first condition, and mathematically constitutes one of the equations of the analysis.

Secondly, since the aeroplane is losing weight in fuel during its flight, its velocity will not in general remain constant for the trip, so that the total distance flown will not simply be the product of the velocity and the time, but must be expressed as the time integral of the velocity between the limits zero and the total time occupied for the journey. This will then constitute another condition and may be written in the form of a second equation.

Thirdly, we assume for convenience that the height at which the aeroplane flies remains constant for the greater part of the journey, *i. e.*, that it is flying level at some pre-determined altitude. In order to attain a sufficient height at which to fly, and to retain sufficient reserve power in the motors a fourth condition is introduced; and fifthly, we know that the aeroplane is flying at its "top speed" all the way, such top speed being dependent upon:

(1) The height at which it is flying.

(2) The degree of throttling employed on the motors.

(3) The portion of the flight considered.

In this way it is possible to obtain mathematically a general solution of the problem, giving the total distance as a function of three independent variables, viz.:

(1) The initial total weight of the aeroplane.

(2) The supporting area of the wings.

(3) The height above sea level at which the flight is to take place.

By the theorems of the differential calculus it is then possible to estimate:

(1) The most economical total weight to employ.

(2) The most economical wing area.

(3) The best height at which to fly.

Conditions (1) and (2) immediately settle the problem of size, which is the problem we originally set out to solve.

The foregoing is intended to show that the problem of the best type of aeroplane to employ is capable of an approximate mathematical solution on the lines indicated. When this has been accomplished and the general solution obtained, construction becomes simply a matter of careful detail design.—*London Times Engineering Supplement.*

The Raleigh Tercentenary

The tercentenary of Sir Walter Raleigh's death was celebrated on Sunday, October 27, by a special service at St. Margaret's Church, Westminster. The service was arranged by the Tercentenary Committee, of which the King is patron, Mr. Balfour, one of the honorary presidents, and Prof. Gollancz, hon. secretary. Two wreaths in memory of Sir Walter Raleigh were laid before the service at the foot of the Communion-table, where the body is said to have been buried. One was from the Tercentenary Committee; the other, of laureis, was from the Royal Geographical Society, and was inscribed: "To the memory of Sir Walter Raleigh on the tercentenary of his death." It was borne by Sir Thomas Holdich, K.C.M.G., and Mr. Arthur R. Hinks, secretary of the society. The address was delivered by the rector of St. Margaret's, Canon Carnegie. Memorial services were also held at the Temple Church and at Woolwich Parish Church. The work of Raleigh in exploration and colonisation was also commemorated on Tuesday by meetings at the Mansion House and elsewhere. At the Mansion House meeting Sir Charles Wakefield (hon. treasurer of the Tercentenary Committee) offered for the acceptance of the Lieutenant of the Tower a copy of Raleigh's "History of the World," which he hoped would find a place in the room where the history was written. He offered to the British Academy as the nucleus of a Raleigh Fund for History the sum of 500*l.* a year for at least the next five years, in the hope that it might not only advance historical learning among our fellow-citizens, but also help forward intellectual co-operation between American and British soldiers. He would only stipulate that at least one public lecture be delivered annually, to be named after Raleigh.

At the Devon celebration of the tercentenary held at Exeter, Lord Fortescue, president of the organising committee, announced that he had received from Mr. Walter Peacock, Secretary to the Duchy of Cornwall, a letter to the effect that he was sure the proposal to celebrate the tercentenary would commend itself to the Prince of Wales and his Council, and suggesting that the proposed new University of the South-West should be styled the Raleigh University as a monument worthy of the man. Resolutions were carried that funds should be invited to this end, and a widely representative committee was appointed to co-operate with the existing committee for the furtherance of university education in the South-West.

Born of Devon parentage about the year 1552, Raleigh was the half-brother of Sir Humphrey Gilbert, another famous adventurer. In early life he served as a soldier in Ireland, but soon conceived plans for forming settlements in America, animated largely by hostility towards the Spaniards. An expedition sent by Raleigh to Newfoundland in 1583 resulted in the death of Sir Humphrey Gilbert. Raleigh then received from Queen Elizabeth the patent granted five years before to Gilbert to take possession "of any remote barbarous and heathen lands not possessed by any Christian prince or people." Quick to take advantage of his opportunity, he sent an expedition to America the same year. This expedition made a landfall in Florida and followed the coast northward to Pamlico Sound in North Carolina. A large tract of country which he did not reach Raleigh named Virginia in honor of Queen Elizabeth. In 1585 colonists were sent to Roanoke Island, but they soon had difficulties with the Indians, and the settlement proved a failure. Later attempts, in 1586 and 1587, met with no better success, and in 1589 Raleigh sold his rights in Virginia. Raleigh's next voyage of exploration was to South America in 1595, where, fired by stories of El Dorado, he hoped to find gold-mines. His "Discoveries of Guiana" gave an account of his expedition. Soldiering occupied Raleigh for some years, and, though high in Court favor, he was disliked in England for his arrogance and reputed greed. Soon after the accession of James I. he was accused of conspiracy and sent to the Tower. Many years later he was liberated in order to make a voyage to Guiana on the promise that the discovery of gold would obtain his freedom. The expedition achieved little, and Raleigh returned home and was beheaded in 1618. Gain and the hope of plunder were largely Raleigh's motives in his colonising enterprises, for he was in reality a pirate adventurer, but his work was of great importance in preparing the way for others and in helping to lay the foundations of Britain beyond the seas.

In connection with the tercentenary celebrations it is natural that some allusion should be made to the services Raleigh is commonly believed to have rendered to his country by introducing the potato. In the aggregate the literature of this plant would form a long series of volumes, and that dealing with its introduction into Europe and the British Isles is so copious that only the patient and leisured would care to study it thoroughly. This copiousness arises, no doubt, from the fact that, in spite of the reiterated statement that Raleigh brought the potato from Virginia, there is ample ground for controversy, and controversy there has been, leaving us very much shaken in our faith in the generally accepted account of its introduction by him. The appearance of the potato in the British Isles is supposed to date from 1586, and the tercentenary of its introduction was celebrated in 1886. But the first evidence we possess to show that the tuber was in cultivation in this country is that afforded by the catalogue of the plants in Gerard's garden in Holborn, published in 1596. Gerard, in his "Herball" of 1597, describes and figures it under the names of "Batatas Virginiana sive Virginianorum & Pappus, Potatoes of Virginia," and tells us that "it groweth naturally in America, where it was first discovered, as reporteth C. Clusius, since which time I have received rootes hereof from Virginia."

We learn from Clusius that the potato was cultivated in Italy in or about the year 1585, having probably been obtained from some Spanish source. It was taken to Belgium in 1586, and some tubers came into the hands of Philippe de Sivry, the prefect of Mons, who cultivated them, and sent, eary in 1588, two tubers to Clusius at Vienna. It is thought that Gerard did not obtain the potato from Clusius, but, if the former may be trusted, it was obtained direct by him from Virginia. Gerard, however, is known to have handled the truth at least carelessly, and if he did not deliberately make a misstatement with regard to the origin of the plant, he was indifferent about it, and possibly wilfully suppressed information that would have elucidated the point. Introducers of plants of commercial value in later days have not always been quite candid as to their source. Gerard was probably proud of his possession of the potato, for his portrait, published in the "Herball," represents him as holding a flowering branch of the plant in his hand, and, for some reason obscure to us, may not have been disposed to divulge its origin. The late Sir James Murray, with his usual thoroughness, investigated the question of the introduction of the potato in connection with his article on the word in the New Oxford Dictionary. He says that Gerard "was in error in his statement that he obtained it from Virginia. In 1693 its introduction into Ireland was attributed to Sir Walter Raleigh after his return from Virginia (where he never was); but no contemporary statement associating Raleigh's name with the potato has been found."

It appears probable that the potato first reached this country as a result of one of Drake's expeditions to the New World, and it may have been brought on the vessel which, in 1586, conveyed to Plymouth the survivors of the ill-fated British colony in Virginia, and in the course of the voyage was probably taken with other booty from some Spanish ship. Drake as the introducer of the potato is so far accepted that a monument to him in commemoration of this was erected at Offenburg, in Germany, in 1854. It is extremely doubtful whether Raleigh had really any direct part in the introduction of the plant, but, according to Dr. Brushfield's painstaking researches, published in the Transactions of the Devonshire Association for the Advancement of Science (vol. xxx., pp. 158-97, 1898), it would appear that he was instrumental in extending its cultivation in this country and in popularising the tuber as a valuable food. He even says: "That Raleigh was the direct cause of the potato being brought to this land of ours can now scarcely be gainsaid; and to him must certainly be attributed the honor of promoting its cultivation in Ireland, from whence it was subsequently transmitted to England."

An interesting and able article on the subject written by Dr. B. Daydon Jackson, appeared in the *Gardeners' Chronicle* in 1900 (vol. xxvii., pp. 161-62 and 178-80).

It is certainly as a populariser of the practice of smoking, and not as the introducer of the plant, that Raleigh should be remembered with reference to tobacco. Its introduction was accomplished by Sir John Hawkins in 1565, and Raleigh early acquired the habit of smoking, which he succeeded in introducing to Court circles. Dr Brushfield writes: "There can be no hesitation in affirming that Raleigh not only introduced it [tobacco] into general use in this country, but . . . was the first that brought it into fashion."—*Nature.*

Intensive Prune Cultivation Under Way in France

The cultivation of the prune in France is said to have been started at Clairac, in the Department of Lot et Garonne, by monks of that region. The principal varieties now grown are the prunes d'Ente, prunes d'Agen, and prunes robe de Sergent. Formerly the prunes du Roi and prunes Saint Antoine were also cultivated, but these varieties have been largely discontinued because they are more difficult to cook.

For processing, the fruit should be quite ripe before gathering. This fruit, especially the prune d'Ente, is generally found in the best condition for use in September. It seems preferable to let it ripen and fall naturally, as it is then easier to preserve, richer in flavor and color, and heavier in weight.

If the fruit remains too long on the tree it is shaken down, but to prevent injury straw is spread under the tree, or the ground is softened. The prunes must be picked up promptly, at least once a day under each tree.

They are then spread out for a day or two in a dry place, and afterwards placed in ovens, to complete the drying. Formerly bakers' ovens were used, but others specially suited to the purpose have now been constructed.

Three periods in the ovens are necessary, the first two to remove all the water in the prune, and the third to cook it. During the first period the temperature must not exceed 45° to 50° C. (113° to 122° F.), during the second period, 65° to 70° C. (149° to 158° F.), and it is said to be very important that the temperature should not exceed the latter mark. After each of these periods the fruit must be exposed to fresh air, and it is necessary to avoid disturbing the fruit while it is warm. The third period, to cook the prune, must have a temperature of from 80° to 90°, or even 100° C. (176° to 194°, or even 212° F.).

This operation must be conducted carefully to avoid burning the fruit. The length of each period depends upon the condition of the prunes, but is generally about six hours.

The prunes are next separated into eight classes, or grades, depending on the size of the fruit. The class is determined by the number of prunes necessary to make a French pound of 500 grammes (1.1 lb.). Prunes of the superior first grade require but 30 to 35 to the French pound, while there are 40 to 45 of the ordinary first grade; second grade, 50 to 55; third grade, 60 to 65; fourth grade, 70 to 75; fifth grade; 80 to 85; sixth grade, 90 to 95; seventh grade, 100 to 110; and eighth grade, 120 to 125.

The prunes are usually packed in wooden cases of 14 kilogs 200 grammes (31.2 lb.), having a net weight of 12½ kilogs (27½ lb.). For South American trade, cases of 50 kilogs net (110 lb.) are sometimes used, but only for the lower grades of fruit. Decorated tins of half kilog (1.1 lb.) and glass jars are sometimes also used to cater for special demands, but at present special containers are too expensive for profitable use.

Non-Inflammable Plastic Material

A recent French patent describes a new plastic material which is non-inflammable and odorless. The material is obtained by transforming gelatines, glues, and such substances of animal origin by suitable chemical reagents, giving them plastic and malleable properties which allow them to be used industrially in a manner similar to natural products.

The gelatines or glues are first melted in a water-bath at a temperature of 90 degrees C. A decoction of hop flowers is then prepared and mixed with dilute oxalic acid or any dibasic acid of that series, and the solution is added to the melted gelatines or glues in varying proportions, according to the quality of the materials employed. The addition of this solution has the effect of rendering the gelatine more supple, and of causing the impurities they contain to deposit at the bottom of the vessel. When the gelatines are liquefied they are poured out in the form of sheets or sticks of the desired thickness and left to dry in the cold air. The coloring of the material is then proceeded with, natural or artificial dyes being employed. The sheets, when colored, are plunged into a bath of approximately the following composition: 25 to 35 per cent formaldehyde, 25 to 35 per cent water, 25 to 35 per cent alcohol, and the rest composed of a mixture of oxalic acid, tannin, and glycerine.

The oxalic acid may be replaced by any other acid of that series. The plates should be left in this solution until the liquid has penetrated into the entire plastic mass. In the case of rich gelatines, the proportion of alcohol must be increased. The sheets, when taken out of the bath, are dried, preferably in hot air. The substance, when suitably worked, may serve for the manufacture of combs, buttons, brushes, etc., as an imitation of tortoise shell, horn, amber, or ivory, and is unlike other cellulose products used in industry in being absolutely non-inflammable and odorless.—*Chemical Trade Journal and Chemical Engineer.*

Photos by Author; By courtesy University Museum, Philadelphia

Macoa girl spinning cotton thread

Indian boys making string figures

The Macoa Indians of Venezuela—III*

An Expedition Among a Little Known But Ancient Race

By Theodoor De Booy

[Concluded from Scientific American Supplement, No. 2245, Page 26, January 11, 1919]

The Macoa women were especially expert in the weaving of cotton cloth. While they did not ornament their fabrics with the intricate conventionalized animal figures that are found on the textiles of Ecuador and Peru, the straight line patterns were far from unattractive. The method of manufacture was somewhat as follows:

The cotton was collected from plants that had been cultivated on the clearings, and I noted especially that the variety that was grown had an unusually long staple and appeared to be of excellent quality. After collecting the pods the women would spread these upon the woven sleeping mats, and would then gin the cotton by means of flat sticks. By constant beating with these sticks the seeds and impurities were removed, until finally naught remained but the pure cottonwool. This wool was then spun into thread by means of the spindle-whorl method, which has been in vogue in South- and Central-America since the dawn of time. The method consists of revolving a weighted stick in such a manner that the cottonwool, which is fed toward the end of the spindle, twists itself into a thread.

The thread once made, it is now either used as it is, or else dyed brown by means of a vegetable pigment derived from the bark of a tree. In either form the threads are then strung lengthwise on the loom, making what is known as the "warp" series of colored thread alternating with those that are plain white. After this operation the "woof," or crosswise threads are woven through the warp, finally resulting in the completed product. The threads for the woof had been wound on shuttles, and by means of weaving sticks every alternate thread of the warp was separated and the shuttles passed through. The whole method was, of course, very slow, and it took two women about three weeks of steady work to complete one man's size robe. The woven headdresses of the men were also made by this method, with the exception that the loom was far smaller and narrower.

Due to internal strife the Macoas have moved so frequently from place to place in the last few years that their cotton crops have been failures, and as a result they are very short of cotton for the weaving of their robes. The entire tribe was in rags and tatters when I came among them, and my gifts of cotton goods, which I had brought with me for trading purposes, were highly appreciated. A few words regarding these trading goods may not be amiss. In the first place I had purchased a supply of jewsharps, cheap jewelry, bead necklaces, pipes and loose beads in Maracaibo. This was supplemented by a quantity of cheap and highly colored calico and numerous bright handkerchiefs. Later on, when I sent a Tucucu or two to the lowlands in order to keep in communication with the outside world, I arranged for supplies of heavy cotton cloth from Machiques. I furthermore sent for a supply of blankets, which were most welcome gifts and highly prized by the older members of the tribe who felt the intense cold of the nights more acutely than did the younger Indians. Should any future traveler penetrate this region he is advised to carry with him a supply of hoop-iron, cutlasses, sheath-knives and large beads in addition to the articles already enumerated. A miniature talking machine might also be a welcome innovation to the Macoas, and the newcomer would undoubtedly rise in their esteem by playing selections on this instrument. I only wish that I had thought to bring one of these with me, as it not only would have given joy to the Indians, but might have proved a welcome relief to me from the monotony of the Indian music.

Macoa boys playing two varieties of flutes

Music plays a large part in the life of the Macoas. Their instruments are restricted to flutes and conch-shells, instruments of percussion such as drums being unknown to them. Various types of flutes and panpipes are used. The only instrument played by the women are the panpipes, and these are not played by the men. The latter use three types of flutes. The simplest type consists of an open bamboo reed which is held against the lower lip; this instrument produces only one note. The next instrument is a bamboo reed, closed at the top by a piece of beeswax with a quill-mouthpiece. Three or four holes have been burnt in the reed, so that a corresponding number of notes can be produced. Finally, the Macoas have a more elaborate flute with a rounded airchamber made of beeswax which is attached at right angles to a long bamboo tube. A quill mouthpiece is fastened to the airchamber. This instrument has an extremely low pitch and can also produce from three to four notes. The Macoa music is monotonous to the extreme, and while the Indians assured me that they had different tunes, and even tried to demonstrate to me wherein the difference lay, I failed to note that one tune did not resemble another. I succeeded in varying the monotony by introducing "jewsharps" which I had among my trading goods, and while the Macoas were of course not acquainted with this instrument, they proved apt pupils and soon learned to reproduce their tunes on it. Luckily the jewsharps were soon broken, whereupon the Indians hung the instruments on their necklaces as charms, and were just as pleased. I wish the same results could have been attained with their flutes which were constantly being played upon. Finally, the Macoas had large conch-shells (*strombus gigas*) which they used for

signalling and for notifying the other members of the tribe of an approaching chica-feast.

The Macoas excelled especially in the making of baskets of various types. This work was done exclusively by men. The larger baskets were used for the transportation of foodstuffs and of calabashes filled with water, and were suspended on the back of the carrier by means of a woven cord which went over the forehead. Even the smaller girls were made to carry loads in this manner and it was a common sight to note a small infant of five bring in the day's supply, frequently transporting as much as two enormous calabashes with perhaps thirty pounds of water in a basket. Other types of baskets were made and used for all purposes, practically all the household goods of the Indians being stored in these containers. The material from which all baskets were made consisted of strips of the stem of a certain variety of palm which is found throughout the interior of the Perijà mountains.

The Macoas are extensive users of gourds and calabashes for all culinary purposes and always have large supplies of these on hand. Gourds are cut in two and then used as foodbowls, cookingbowls and spoons, while the calabashes are left entire and employed for the storing of water, maize and so forth. Some of the calabashes are of enormous size and will store as much as five gallons of water. These various utensils are frequently decorated with incised designs representing conventionalized animals and other figures.

One of the favorite amusements of the younger Macoa boys consisted of the making of string figures, and they produce the most intricate designs in this manner. I succeeded in photographing and classifying five different figures, to the huge delight of the boys who took an intense interest in having their pictures taken and seeing the negative afterwards. Strange to say the only other region in South America where string figures are known to be made are the Guianas on the northeastern coast of the continent. In comparing the Macoa figures with those that have been illustrated in various works on the Guiana Indians it will be found that while the general technique of preparing the designs is the same, the figures themselves are materially different. The Macoa boys appeared to be especially desirous of speed in producing the figures, and would laugh heartily whenever one of their number either failed in the figure he was attempting or else made it too slowly to suit his companions.

The Macoas apparently did not have any medicine-man and their woes and ills were cured by infusions from herbs that were collected by the older women of the tribe. None of the complicated ceremonies that are so beloved by the generality of South American Indians were known by these aborigines, and only the simplest medicines were used. Of these wet tobacco played perhaps the most prominent part; this was plastered on the body in spots where pain was felt. Another Macoa favorite was an aromatic bark, a piece of which was always suspended over the hammock-cradle of the infants. This bark was also powdered and sprinkled on the heads of infants as a preventive against colic and such like complaints.

One of the most curious customs of the Macoas is that these Indians cut their hair short, men and women alike. We find as early as the seventeenth century a mention by Fray de la Rosa that the Motilone Indians were so named from their custom of cutting the hair, the name signifying "cut-haired" according to this historian. De la Rosa also states that the custom originated when a small-pox epidemic struck the Indians, who then cut their hair by the advice of a missionary priest who was working among them. This explanation however seems to us to be rather far fetched, as there would have been no reason for the Indians to continue the custom subsequently.

The religious beliefs of the Macoas are not complicated. They believe in a Supreme Being whom they call "Kioso," and also in evil spirits. They have, however, no such thing as worship of either good or bad spirits, and on the whole treat matters of this kind very calmly. About the only time one notes that the Macoa gives a thought to spiritual matters is when thunder and lightning visits his domains. On hearing an especially loud clap of thunder the Macoa will look upward and exclaim "Kioso èsop," which means "God is angry."

Macoa playing a chica flute

Macoa women weaving a robe

A small native loom

On the other hand superstition plays a great part in the daily life of these Indians. Certain signs which they consider unpropitious will make them turn back from a contemplated hunting expedition. Or should a Macoa kill an enemy in battle, he will change robes with some friend at the earliest possible moment, it being his belief that unless he does this the spirit of the slain adversary will settle on his robe and pursue him with bad luck. Again, it appears to be the worst possible kind of luck to weave but one fan or to manufacture but one lice-comb. For some reason known only to the Macoas, and which neither they nor the Tucucus could explain to me, fire-fans and lice-combs are always made in duplicate. I benefited greatly by this idea when it came to forming collections of the arts and crafts of the Macoas, and was only sorry that the same rule did not apply to all the various specimens produced by these Indians. Another favorite superstition of the Macoas was that fire should never be extinguished by means of water. I learned of this when I poured the contents of a calabash over my campfire one night in order to stop the smoking of a green log. The witnesses of this act were horrified and assured me that there was a great possibility of my dying from the cold afterwards.

The Macoas were not especially rich in folklore. They had one or two tales which the older people would relate to the children, and these stories generally centered around an Indian youth named Osèma, which word means "earthquake" in the Macoa language. One of these stories, as related to me by a Tucucu, was as follows:

"Osèma had maize (corn) in his hair, and when he wished to eat he used his lice-comb and combed the maize on the ground. It is said Osèma planted the maize in a bare place, and the night following the maize had reached maturity and the ears were dry and ready to be gathered. When Osèma went away, after eating maize, he made a flute and he played on this flute. When he was there [reached his destination], food appeared before him without his knowing who brought the food. When he made a meal off the food he ate every part of it, as he could not leave any behind."

The burial customs of the Macoas are connected with but few ceremonies. The customs for burying men are similar to those for burying women. The corpse, which is interred on the same day that death takes place, is buried in a hole about five feet wide and three feet square. It is buried in an embryonic position, in its robes, with a rope tied around it in order to keep the body in position. A cord is also bound around the head in order to prevent the chin from falling. The arms are flexed and the hands placed along the cheeks. All personal ornaments are buried with the departed, but no arms or food.

One moon afterwards the body is exhumed. By this time the ants have cleaned the bones. The skeleton is now collected and tied up in a sleeping mat, together with the personal ornaments. The mat is tied with cord at the ends and in the middle and the place where the skull is, is marked with charcoal to denote the position of the eyes, mouth and nose. The package is then placed in the rooftree of the hut of the departed where it hangs for one entire day. During this day a chicha feast is held by the Indians, who also take turns in dancing with the package suspended on their backs. When the feast is over the package is taken to some far-off place where it is deposited under an overhanging cliff.

If the departed was a man, his wife shaves her head and uses no face-paint for a month. A husband would follow a like custom. The survivor generally does not marry again for another year. For a month afterwards the survivor must not touch any food with his hands, but must extract it from the foodbowl by means of a small pointed stick. Nor can the survivor scratch himself with his hand during this period. This act also has to be performed by means of a small stick. Food for the departed is placed on a stone for some time after death has taken place.

The study of the Macoa language proved to be a fascinating occupation and one which was as amusing to the instructor as it was to the pupil. The Macoas would gather around whenever I produced my notebook and hurriedly call a Tucucu interpreter into service. I would then give the Tucucu a Spanish word and he would tell me the Tucucu word which was the

same as the Macoa. This I would then write down phonetically, and great was the delight of the aborigines when they discovered afterwards that I could repeat the word from my notebook. In all some 350 words and expressions were collected, which may prove of future aid to a prospective traveler in any part of the Motilone territory.

At last the time came for me to say goodbye to my Indian hosts. My trading goods had all been used up, I had a representative collection of all ethnological material that was made by the Macoas and I furthermore felt that a longer stay might become dangerous. I had seen enough of these particular Indians to realise that their character was somewhat fickle, and that their professed friendship of today might turn into their avowed enmity of tomorrow. The novelty of my being among them had worn off, they were aware of the fact that the stock of trading gods had given out and another chicha-feast was imminent. The thing to do therefore was to arrange for a number of carriers to transport the collections to the lowlands. It took thirteen men and two boys in the end to do this, and as the Macoas absolutely refused to undertake the final part of the journey, we were forced to leave some of the loads at a distance from Mr. Garcia's cattle-ranch until the Tucucus could make several trips to and fro and bring in the loads of the Macoas. The arrival at the cattle farm was the sign for the departure of the Tucucus who were anxious to join the waiting Macoas on the crest of the last range. Mr. Garcia was not unduly surprised at my arrival, as I had sent a Tucucu down the mountains a week previously to advise him of my coming. But in Machiques the surprise was intense, and my Venezuelan companion was greeted as one who had returned from the tomb.

It would be hard for me to say whether or not the Indians were sorry to bid me goodbye. Some of them seemed to be, while others appeared to have the utmost indifference. For my part I was sorry to see the last of my hosts, for with all the excitements we had had in the Macoa camp, I could not forget that the aborigines had fulfilled their part of the contract; they had given me food while living with them, had formed for me a wonderful collection of their artifacts, and last, but by far not least, had deposited me safely in the lowlands at the end of my visit. May they continue to live their savage lives in the interior of the Sierra de Perijà, unacquainted with the sorrows of civilization and undisputed heirs to one of the few regions in South America where the aboriginee still rules!

The final phase of my anthropological work in the Perijà district consisted of making an archeological survey in the lowlands. This was done in order to gain some information regarding the population that had lived in these parts previous to the discovery of the Americas. According to some of the inhabitants of Machiques evidence in the shape of potsherds was to be found on a small hill between Machiques and the Macoita River, at some small distance from the place where this river breaks through the last barrier of the Sierra de Perijà. The hill was named Pueblo Viejo (Old Town), a further indication that this might prove a fertile field for archeological research. In consequence I had a couple of huts built near this site and moved myself and my laborers to the locality. The first thing done was to make a careful survey of the land in order to discover the best place in which to start work. I was soon convinced that there would be no possibility of doing any excavating, as the ground was exceptionally hard and rocky and had not tended to preserve any of the more fragile specimens of Indian workmanship. The work therefore consisted of a careful scouring of the surface by my laborers and the picking up of all potsherds, stone axes, mortars and similar specimens. To do this as well as possible I was obliged to set fire to the savanna-grass with which the site was covered, and then to await a rain which would dissipate the resulting ashes. When this had taken place the work was easy and merely became a matter of good eyesight. I would spend the evenings in picking over the collected artifacts and discard those that had no scientific value. During the day, while the laborers were at work, I would ride throughout the country side and hunt for promising places in which to conduct future excavations. These rides resulted in the finding of a pre-Colombian cemetery and several Indian refuse heaps. It was found that the Macoa civilization was preceded by another, higher culture, that of the Arhuacos, who were far better workers in clay and stone than the cruder races which subsequently inhabited the district.

On top of the "Pueblo Viejo" hill were found the ruins of an old Spanish building consisting of about five rooms. The walls were not standing, but one can still note the bowlders from which the walls had been constructed and the regular lines in which the walls had been laid out. I deducted from these remains, and from the quantities of Indian artifacts that were scattered on the site, that here was found, in all probability, one of the ten missions of the Capuchin friars that were at one time established among the Motilones of the lowlands. Brief mention of these missions is found in some of the old historians who state that all attempts at civilization of the Motilones turned out to be failures, and that finally the Indians revolted and massacred the missionaries and destroyed their buildings. It becomes an interesting conjecture whether the friars of Pueblo Viejo were massacred, or whether they voluntarily abandoned their home. We fear the former was the case.

The Age of the Earth

(Concluded from page 35)

or otherwise, are incapable of prolonging the solar radiation sufficiently to meet geologic requirements.

We are left, then, with two main sources of solar energy: (1) gravitational contraction, which we must admit is quite inadequate in the light of earth history and of the direct observations that will be mentioned later; (2) "unknown" sources, which we are prone to consider quite sufficient for all requirements, and which are, in fact, often freely and vainly discussed under the vague designation of "sub-" or "infra-" atomic. Further elemental disintegrations, because of the peculiar high-temperature and electrical conditions of the Sun, may be proposed as the energy source—or the complete or partial transformation of mass, by some magical means, into free radiant energy—or other similarly indefinite plans for unraveling the secret of the storing up and realeasing of the observed energies of suns. It is hardly probable that we shall long be without the solution of this problem, or at least we may expect an acceptable, workable, and non-magical hypothesis; and when it comes (with its probably enormous consequences) it is to be hoped that our present laws and tentative theories of stellar radiation will not prove to have been wholly unavailing.

OBSERVATIONAL INQUIRIES RELATIVE TO STELLAR RADIATION.

Whatever may be the explanation of the energy radiated by the stars, it now appears as a fairly definite result of direct observation that the amount of radiation is so great that only a minute percentage can be supplied by gravitative contraction, infall of meteoric matter, primitive heat, radioactivity, and other recognized atomic sources. One observational result comes from astronomy, another from geology; the latter seems more decisive because of the greater interval of time involved in the test.

From the time of the first spectroscopic studies of stars, the different colors and spectral types were accepted as representing different stages in stellar evolution. The life of man and of his present astronomical records were recognized as too brief to prove directly the change in spectrum as stars grow old; but the continuous gradations from type to type, combined with extensive information as to motions and brightness and chemical nature, left little doubt that, given time enough, a typical star will progress through many of the spectral stages now observed as essentially static. The actual variation in spectral characteristics of Cepheid variables is periodic rather than secular, and the spectral changes of Novae appear to be catastrophic rather than normal.

Observation and theory alike permit the arrangement of the typical spectral types into a presumably definite evolutionary sequence—Russell's astrophysical hypothesis of the order of development being strongly supported by Eddington's mathematical analysis and by vast and varied quantities of observational material. The mathematical theory, based mainly on known properties of gases, naturally involves directly in its present form only known sources of energy. Fortunately the theory permits estimates of the speed of spectral development, and it is when this theoretical result is compared with certain geologic and astrophysical evidence that we bring to light the glaring discrepancy mentioned above. We shall first describe the astrophysical test.

Suppose a star, exactly similar to the Sun in all respects including the date of origin, were so distant that a great interval of time were necessary for its light to reach the Earth. A study of the two stars by a terrestrial observer would involve a comparison of the youth of the distant star with a more advanced age of the Sun; and, if the evolution is fast enough and the observation sufficiently refined, there should be direct evidence of stellar change. The test obviously cannot be used on the nearby stars ordinarily studied because, first, we do not know that any one of them closely resembles the Sun (or another star) in all respects, and second, their distances from the Sun (or each other) of some hundreds of millions of millions of miles are entirely too small to show measurable change in stellar radiation during the corresponding hundred or so years necessary for the passage of their light. The method may be applied, however, in a qualitative way to the highly luminous giant stars of distant stellar clusters. Eddington has computed that with known sources of energy a hundred thousand years is sufficient for the development of a giant star through all spectral types to the stage where it no longer behaves as a perfect gas. Since the development presumably is slower for the more advanced stage represented by the Sun, the giant stars are more suitable for the observation of evolutionary change.

Recent studies of globular clusters show their approximate similarity in size, form, and stellar content. We have also learned to estimate their distances, and find them exceedingly remote from the Earth and from each other.[12] From the list of 80 known globular systems, I have selected those for which the numbers and colors of their giant stars are known, expressing in round numbers the distance of each from the Earth in terms of the number of years required for the transmission of its light across intervening space:

Messier 22,	25,000 years
Messier 13,	35,000 "
Messier 5,	40,000 "
Messier 3,	45,000 "
Messier 15,	50,000 "
N. G. C. 7006,	220,000 "

[12]*Mount Wilson Contributions*, Nos. 151-157, 1917-1918.

As observed from the Earth, these clusters differ in age by the differences in the tabulated numbers, the first being nearly two thousand centuries older than the last. If, as the theory predicts, it takes but 25,000 years for the change of a giant red star into a giant yellow star, we should find evidence of such progression in the photometric study of these typical giants of globular clusters. None is found, however, as the frequency of giant stars of all colors is much the same in all six clusters. It would therefore appear that, ignoring improbable alternatives, such as the supposition of an equilibrium in color statistics by means of a continual creation of giant stars, this observation must be considered as direct qualitative evidence of slow evolution. To be sure, we do not know the time of origin of these systems relative to each other, but that it is in any way dependent upon distance from the Earth is too improbable to believe.

The similarity of color statistics for the bright stars in globular clusters thus bears on the inadequacy of known energy sources in accounting for the observed radiation phenomena of gaseous giant stars. The paleo-meteorology of the Earth bears on the same problem for the Sun itself, and therefore for the "dwarf" stages in stellar development. It appears, moreover, that this geologic evidence is much more definite and incontrovertible than the somewhat provisional results from clusters; and to a limited extent it may be quantitative. The case is briefly stated.

The new time scale shows that the fossil-bearing rocks of the Paleozoic era were formed some five hundred million years ago. Animal life was then already far advanced compared with its earliest unicellular stages. At the beginning of the Cambrian period all the invertebrate phyla had become differentiated, and the degree of evolution up to that time is generally conceded to have required at least as great an interval of time as all the succeeding ages. Aside from the duration of time, a requisite for the slow development of plant and animal forms in moderate climatic conditions during all the eras of the past, and that such was the case is amply attested by the records of the rocks. Hence the distribution of ancient life, the seasonal effects in the old formations, the characteristic products of denudation, the petrified imprints of the rain drops of Paleozoic showers, all testify against pronounced non-cyclic alteration of terrestrial climate since Archeozoic days. We may be sure, Holmes declares (p. 114), that for at least as long as the Earth has been a habitable globe, so long has the Sun emitted its life-giving rays at a rate not very different from that of the present."

The consequences are obvious. The Sun has certainly not been a highly lumious giant star during geologic time; nor has it been a dwarf in luminosity. In fact, the evidence suggests that it has been stationary in temperature, light-emission, and spectral type

since the recoverable records began in the Earth's crust. Possibly we may assume a stabilizing effect of the Earth's atmosphere that might allow in the surface temperature of the Sun a range of a few hundred degrees without dire consequences for terrestrial life. A difference of even a single spectral type, however, would correspond to a change of several hundred per cent. in light-emission, and that appears to be wholly out of question. I believe we may assume, therefore, that the time required for the Sun, or any similar star, to change in spectrum from G0 to G5, or from G0 to F5 (whichever way it is going, and if it goes!), is not the few million years provided by existing theory but is indeed far in excess of a thousand million years.

If such is the case a new point of view of the expanse of time enters problems of sidereal systems. During the formative period of stars and stellar groups their wanderings in space, as indicated by observed velocities, may be very far. The globular clusters, to which we may possibly look for the origin of our galactic system, have completely changed in distribution since the first known vertebrates appeared in the Ordovician fauna. If its present high velocity of approach has always been about the same, the great Hercules cluster, which now is visible to the unaided eye at a distance of less than 40,000 light-years, was probably more than a million light-years distant when life first appeared upon the Earth; it was scarcely a thousandth as bright then as now, it was much less than a minute of arc in diameter, and would have appeared as a faint hazy star in the largest of modern telescopes. The Sun at its present speed would have travelled, since the origin of the Earth, much more than a hundred thousand light-years, and probably many times as far since it itself came into being. We know something of its direction of motion, something perhaps of its dynamical affinities, and it may be possible with the observational accumulations of the future to trace roughly its past course in space and guess at its earlier environment.

Some Peculiar Thermoelectric Effects*

Paul D. Foote and T. R. Harrison, Bureau of Standards

BENEDICKS[1] has recently published a description of experimental work from which the conclusion was drawn that a nonsymmetrical temperature gradient in a homogeneous wire gives rise to a galvanometrically measurable thermoelectric emf. Dr. Benedicks claims priority for this discovery and proposes the following table as a summary of the discoveries in thermoelectricity.

TABLE 1

DISCOVERIES IN THERMOELECTRICITY

	CIRCUIT	
	Heterogeneous	Homogeneous
A difference of temperatures (asymmetrical) produces an electric current.	Seebeck, 1823	Benedicks, 1916
An electric current produces a difference of temperatures	Peltier, 1834	Thomson, 1856

Effects of the kind described by Benedicks have been long observed at the Geophysical Laboratory of this city, and at the Bureau of Standards especially in connection with the routine homogeneity testing of thermocouples. We have found that thermoelectric emfs may be developed by touching a hot wire to a cold wire of the same material, by crossing two wires and heating one of the wires near the junction, by drawing rapidly a hot wire over a cold wire, by joining two wires of different diameters and heating either wire near the junction, by filing a groove or a v-shaped depression in a metal rod and heating this portion of the rod, by passing a flame over a wire, and by numerous other methods. The avoiding of these parasitic emfs has made homogeneity testing a matter of some difficulty.

All of these effects are well known and were discovered from half a century to a century ago. Many of them are treated in Wiedemann's *Lehre von der Elektricitait*, vol. 2. They are still of interest, however, because conclusive evidence has not been given for the causes of the various effects observed. Many reasons have been suggested and have been supported by theory and experiment, and no doubt among these many possible explanations one or more are correct, but the absolute proof of their correctness remains to be demonstrated. Thus, for example, Benedicks presents an experimental proof in which he makes use of a magnetic field. The conditions were such that very likely he observed the well-known Nernst and von Ettingshausen effect instead of the pure thermoelectric effect supposed.

The priority for the discovery of these thermoelectric effects probably belongs to Benjamin Franklin and Cavendish,[2] in 1769, or 147 years prior to Benedicks's work. These investigations found that when a hot and a cold bar of the same metal were placed in contact, the cold bar became positively charged, as shown by measurements with an electroscope.

The first evidence of the existence of a current in such a circuit was obtained by Ritter[3] in 1798. In the absence of ammeters a pair of frogs was employed. The twitching of the legs showed that positive current flowed in the circuit, frog leg—cold Zn—(hot Zn–cold Zn)—frog leg.

Since 1800 numerous observers have investigated the subject. Indeed about 1850 of these effects were thought by some, possibly rightly, to be more fundamental than the Seebeck effect, and it was believed that their study would lead to an interpretation of the latter phenomenon. Some interesting names appear in the list of early investigators, for example, Becquerel, 1823; Nobili, 1834; Peltier, 1838; Matteuci, 1838; de Heer, 1840; Gaugain, 1862; Coulomb; Righi, 1875; Knott, 1879; Tomlinson, 1888; Stroud, 1889; etc.

Seebeck, 1826, suggested that the emf developed in a single wire on heating asymmetrically was due to a hardening and softening of different portions of the metal. He found that an emf is developed by heating the juction of two similar wires of different diameters. Magnus, 1851, after a most thorough investigation, believed the emf developed by touching a hot and a cold wire to be due to a change in hardness produced by heating. Jenkin,[4] 1862-3, performed a series of very elaborate experiments identical with those described by Benedicks in 1917. Jenkin concluded that the emf obtained by heating crossed wires due to an oxide film acting with the metal underneath as an ordinary thermocouple, and that a sufficient temperature gradient existed through the film to account for the very large emfs observed. The magnitude of these was emphasized by the statement "to my surprise it was not until I had added resistance equal to that of 2,000 miles of the Red Sea cable, that I reduced the deflections within range of my galvanometer." Jenkin proved that the effect was not chemical or electrolytic. The emf developed by touching hot and cold metal was also explained by a film of oxide. He proved that this latter effect could not be due to static electricity. He recognized that it is questionable to attribute the emfs developed with silver, gold and platinum to surface oxidations and raised the point as to whether the physical property of a metal depends not only upon its temperature but upon the time during which it has been at this temperature Jenkin further advocated the theory of change in hardening of the two metals placed in contact.

Durham, 1872, observed that the magnitude of the emf developed on placing hot and cold metal in contact was proportional to the original temperature difference of the two metals.

Trouton, 1886, considered the emf developed by moving a flame along a homogeneous wire. From an interesting experiment he concluded that the emf is a function of $\partial^2\theta/\partial x\, \partial r$ i.e., of the rate of change of the temperature gradient along the wire, and that an emf galvanometrically measurable could not be developed by a temperature gradient alone however asymmetrical. He suggests that the effect is due to either a permanent alteration in the wire, or, with some metals, to a temporary alteration which lags behind the temperature change. In this he confirms the opinion of Jenkin.

Steel,[5] 1893, under the title "A new thermoelectric phenomenon" describes several of the above mentioned effects, while Turnbull,[6] 1894, calls attention to the fact that these effects have been known for years. Turnbull suggests that the emfs are due to strain, an explanation given by LeRoux, 1867, and others.

Backhmetieff and Stambolieff,[7] 1895, heated a homogeneous wire by an electric current. The heating current was then cut off and the two ends of the wire were connected to a galvanometer while the wire cooled. "The direction of the current was almost without exception opposite to the direction of the original heating current." (!)

An interesting discussion appeared in the German technical journal *Elektro Teknische Zeitschrift*, 1900-4. Egg-Sieberg "discovered" that emfs were developed on heating an iron wire by a moving flame, on touching hot to cold iron, and on heating an iron wire dipping into water—thus causing an asymmetrical temperature gradient. He concluded that since the Thomson effect was established it was quite reasonable to assume that this depended upon the steepness of the temperature gradient. Hence in a homogeneous circuit having an asymmetrical temperature gradient, a measurable emf is developed on account of the gradient coefficient of the Thomson effect.

Schneider, 1904, repeated the above experiments and concluded that the effect was due to oxide. This conclusion was undoubtedly correct, especially in connection with his own work, as the resistance of the wires used increased during heating from 2 ohms to 10,000 ohms, and emfs amounting to a half volt were observed.

Hirschon, 1904, suggested that the above effect was due both to the thermoelectric action of the oxide and metal and to the fact that the oxide acted as a shunt on the iron to which it adhered. He showed that the measured potential difference may be in either direction depending upon the extent of the oxidation.

Rosing[8] investigated the emfs developed by touching hot and cold metals. He observed no emf for lead. For gold, silver, copper, iron, tin and platinum the current flows in one direction in the reversed direction for palladium and German silver, and in either direction for aluminum depending upon the temperature. He relates the effects for these metals to the thermoelectric power relative to lead. The metals of the first group have a positive thermoelectric power, while those of the second group have a negative thermoelectric power. The thermoelectric power of aluminum is either positive or negative depending upon the temperature.

The only new suggestion which the writers are able to add to the confusion already existing is that the sign of the emfs developed upon touching hot and cold metal appears to have some relation to the sign of the Thomson effect.

The object of the present note has been two-fold. First, to call attention to the fact that the existence of many of these curious thermoelectric forces, "rediscovered" every decade, has been well recognized for over a century, and secondly, to point out that no conclusive evidence for their cause has been advanced although nearly all conceivable causes have at times been suggested.

*From the Journal of the Washington Academy of Sciences.

[1]Compt. Rend. 163: 751-3. 1916. Compt. Rend. 165: 391-4. 1917. Rev. d. Metallurgie 15: 329-32. 1918.

[2]FRANKLIN and CAVENDISH. Experimental Observations on Electricity, p. 403. 1769.

[3]RITTER. Gilb. Ann. 9: 292. 1801.

[4]JENKIN. British Ass. Rep. 31: 39-41. 1862. Idem. 32. 173-8. 1863.

[5]STEEL. Science, 22: 256. 1893.

[6]TURNBULL. Science, 23: 91-2. 1894.

[7]Journ. Russ. Phys. Chem. Soc. 27: 1-25. 1895.

[8]ROSING. Journ. Russ. Phys. Chem. Soc. 30: 151. 1898.

The Marbles of Italy

ITALY is one of the world's most famous sources of supply for both art and building marbles, and marble, granite and building stones are the common materials used for buildings in that country. Venice is a fireproof city, built of stone of Istria and marble; and the foundations and first courses, at least, of all palaces, public and municipal buildings, Government and business edifices are of these materials.

Venice is immediately adjacent to famous marble quarries with an inexhaustible supply of raw material, worked by cheap labor. The Istrian stone, which is quarried just across the Adriatic, reaches Venice by the cheapest forms of water transportation, being loaded on sailing barges at the quarries, and disembarked at the exact point where it is to be used.

The most important quarries in the Veneto are at and near Verona, the Veronese red and yellow marbles having been favorite building stones since the time when the Colisseum at Verona was constructed. For building, they rank next to the stone of Istria in popularity, and are true marbles, while the stone of Istria is not a true marble, although a very hard limestone, that is much used in Venice because it resists the action of salt water.

Besides their value for construction, the Veronese marbles are in great demand for decorative work. Among the names of the several varieties of Veronese marbles are white nembro, coral pink, white peach, partridge eye, yellow snail, yellow azure, and paradise.

The 34 Supermagic Square*

Mathematical Recreations of Ancient Origin

By Brigadier-General F. J. Anderson, C. B.

In the progress report of the Superintendent of Hindu and Buddhist Monuments for 1915-16 was reproduced a Hindu magic square, found inscribed on a hidden portion of a lintel, brought to light by a fall of masonry, in the Chota Surang shrine at Dudhai in the Jhansi District, India.

This square, which is said to date from the first half of the eleventh century, is as follows:

7	12	1	14
2	13	8	11
16	3	10	5
9	6	15	4

In addition to the usual claim for such squares that the rows, columns, and diagonals each total 34, the discoverer in this case points out that the sub-squares (*i. e.*, the numbers in the four cells clustered around any point where two lines intersect) each give a similar total, but we shall see presently that this enumeration by no means exhausts the supermagic properties of the square.

The following general definition of the term "Magic Square" is given by Hutton (*Recreations in Mathematics*, 1803), and seems to be generally accepted:

"The name magic square, is given to a square divided into several other small equal squares or cells, filled with the terms of any progression of numbers, but generally an arithmetical one, in such a manner, that those in each band, whether horizontal, or vertical, or diagonal, shall always form the same sum."

Hutton gives various rules, some original, some derived from previous writers, for the formation of such squares, but it will suffice here to reproduce the result so far as a 16-cell square of the first sixteen numbers is concerned:

1	15	14	4
12	6	7	9
8	10	11	5
13	3	2	16

Hutton's 34 Square.

This solution fulfils the requirements of his definition, but it falls short of the claims for the Dudhai square, in that some only of the sub-squares total 34.

Popular attention having been directed to the 34 square by a competition in one of the weekly journals some thirty years ago, the following solution was arrived at:

14	1	15	4
7	12	6	9
2	13	3	16
11	8	10	5

It was found to possess the following, at first sight "supermagic," properties, which I give *in extenso* for the benefit of the curious, without entering into any explanation as to how the possession of certain properties is involved as a natural sequence to that of others. The following each total 34:

(*a*) All rows, columns, and diagonals.

(*b*) All sub-squares of four numbers.

(*c*) The four corner numbers.

(*d*) Parallel semi-diagonals, *e. g.* (1 + 7 + 16 + 10), (15 + 9 + 2 + 8), etc.

(*e*) Parallel quarter- and three-quarter diagonals, *e. g.* (14 + 9 + 3 + 8), (11 + 1 + 6 + 16), (4 + 7 +13 +10), etc.

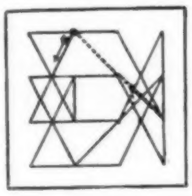
(*f*) Opposite parallel half-sides taken anywhere, *e. g.* (14 + 1 + 11 + 8), (1 + 15 + 8 + 10), (11 + 2 + 16 + 5), etc.

(*g*) The four corner numbers of every square of 9 cells, *e. g.* (14 + 15 + 2 + 3), (12 + 9 + 8 + 5), etc. It may be noticed that the opposite corner numbers total 17, *e. g.* (14 + 3), (15 + 2), (12 + 5), (9 + 8), etc. Hence the two diagonals of any 9-cell square are equal to one another.

(*h*) Similar terminations of any Knight's move on opposite sides of any central line of the square, *e. g.* (14 + 13 + 4 + 3), (12 + 11 + 6 + 5), (8 + 16 + 1 + 9), etc.

(*i*) The sum of the two central numbers in any line, horizontal or vertical, and the two outer numbers of a parallel line next-but-one to it, *e. g.* (1 + 15 + 2 + 16), (12 + 13 + 5 + 4), etc.

In addition to these properties, it is found that the "graph" produced by joining the consecutive numbers 1, 2, 3, etc., in rotation (including the line, shown dotted, joining 16 and 1) forms an absolutely symmetrical figure, thus:



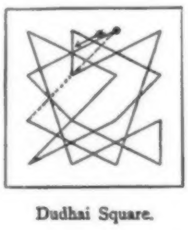
The symmetry of the figure will be the more apparent if it be turned over on its right-hand side.

Now it is to be noted that both the Dudhai Square and that reproduced below, which was discovered on the gate of the fort of Gwalior, share all these properties.

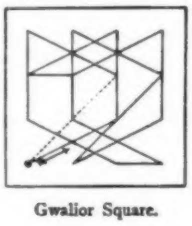
15	10	3	6
4	5	16	9
14	11	2	7
1	8	13	12

Gwalior Square.

Their respective "graphs" are as follows:



Dudhai Square.



Gwalior Square.

The contortions through which any perfect 34 square may be put without any sacrifice of its supermagic properties are somewhat extraordinary. For instance, taking any one primary square, which we will assume to be that shown with the number 1 in its left-hand top cell, we can imagine it inscribed on a cylinder with vertical axis, revolving to the left or right (say the left in this instance), thus bringing each column in rotation into the position occupied by the first column in the primary square, thus:

1	8	10	15
14	11	5	4
7	2	16	9
12	13	3	6

Primary Square.

8	10	15	1
11	5	4	14
2	16	9	7
13	3	6	12

10	15	1	8
5	4	14	11
16	9	7	2
3	6	12	13

15	1	8	10
4	14	11	5
9	7	2	16
6	12	13	3

First Derivatives.

We can then imagine each of these four squares in turn similarly dealt with on a cylinder with horizontal axis, revolving say upwards towards us from the plane of the paper, producing three more forms, thus from the first square:

14	11	5	4
7	2	16	9
12	13	3	6
1	8	10	15

7	2	16	9
12	13	3	6
1	8	10	15
14	11	5	4

12	13	3	6
1	8	10	15
14	11	5	4
7	2	16	9

Example of Secondary Derivatives.

and similarly for the other three squares.

We have now a total of sixteen squares with each of the numbers 1, 2, 3, etc., occupying the left-hand top cell in turn.

Again, we can read each of these sixteen squares in four ways, according to which corner we allot to the left-hand top cell. Thus the primary square may be read as:

12	7	14	1
13	2	11	8
3	16	5	10
6	9	4	15

if we suppose it turned on its right side, or

15	4	9	6
10	5	16	3
8	11	2	13
1	14	7	12

if we suppose it turned on its left side, or

6	3	13	12
9	16	2	7
4	5	11	14
15	10	8	1

if we assume it turned upside-down.

*From Science Progress.

The primary square thus assumes sixty-four guises, each of which has in addition its corresponding reflected, or looking-glass, form, thus raising the total to 128.

We are not yet at an end of the juggling to which our primary square so readily lends itself, for we can imagine its corner sub-squares converted into successive horizontal lines by supposing them unrolled in rotation (*a*, *b*, *c*, *d*) as shown in diagram A, or we can imagine outer opposite half-sides (*a*, *b*) and inner sub-squares (*c*, *d*) similarly unrolled as shown in diagram B, thus producing two new primary squares:

1	8	10	15
14	11	5	4
7	2	16	9
12	13	3	6

Primary Square.

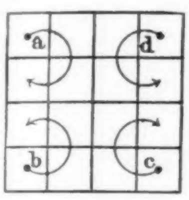


Diagram A.

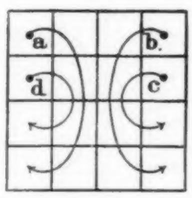


Diagram B.

1	8	11	14
12	13	2	7
6	3	16	9
15	10	5	4

1	8	13	12
15	10	3	6
4	5	16	9
14	11	2	7

New Primary Squares.

Each of these new primary squares also give us a further sixty-four solutions (or 128 if looking-glass forms be included).

The result is a grand total of 192 forms (or 384 if looking-glass solutions be added).

The following Key-Tables (I., II., and III.) present all these solutions in a compact form.

To use them the reader can readily make a stencil by cutitng out of a piece of cardboard a square hole of the exact size required to embrace 16 cells of a key-table.

1	8	10	15	1	8	10
14	11	5	4	14	11	5
7	2	16	9	7	2	16
12	13	3	6	12	13	3
1	8	10	15	1	8	10
14	11	5	4	14	11	5
7	2	16	9	7	2	16

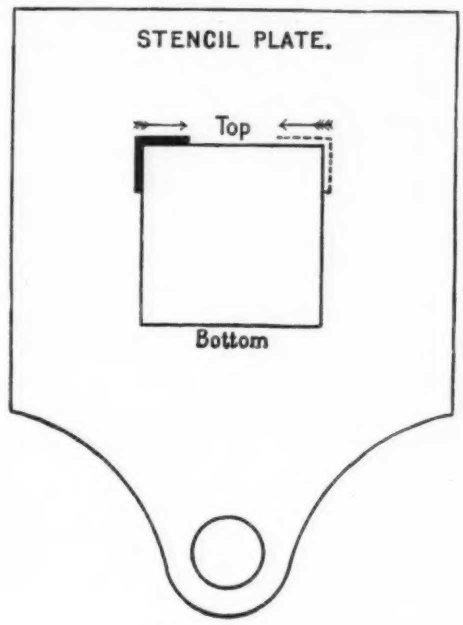
Key-Table I.

1	8	11	14	1	8	11
12	13	2	7	12	13	2
6	3	16	9	6	3	16
15	10	5	4	15	10	5
1	8	11	14	1	8	11
12	13	2	7	12	13	2
6	3	16	9	6	3	16

Key-Table II.

1	8	13	12	1	8	13
15	10	3	6	15	10	3
4	5	16	9	4	5	16
14	11	2	7	14	11	2
1	8	13	12	1	8	13
15	10	3	6	15	10	3
4	5	16	9	4	5	16

Key-Table III.



To illustrate the method of using the stencil: Let it be required to know the forms of all squares having say the number 13 in the left-hand top corner.

Keeping the bottom of the stencil horizontal, and placing the left-hand top cell (indicated by the dark band) on whichever of the two numbers 13 in Key-Table I. does not involve the stencil travelling off the Table, we read, from left to right as indicated by the arrow:

13	3	6	12
8	10	15	1
11	5	4	14
2	16	9	7

Next, turning the stencil so that its bottom occupies a vertical position on the right, we read:

13	2	11	8
3	16	5	10
6	9	4	15
12	7	14	1

Similarly, turning the bottom to the left, we have:

13	8	11	2
12	1	14	7
6	15	4	9
3	10	5	6

and, finally, turning the stencil upside-down, we get:

13	12	6	3
2	7	9	16
11	14	4	5
8	1	15	10

Again, applying the right-hand corner of the stencil (indicated by a dotted border) in a similar, but back-handed, manner, we obtain four looking-glass squares:

13	12	6	3
8	1	15	10
11	14	4	5
2	7	9	16

13	8	11	2
3	10	5	16
6	15	4	9
12	1	14	7

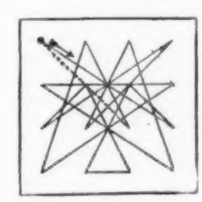
13	2	11	8
12	7	14	1
6	9	4	15
3	16	5	10

13	3	6	12
2	16	9	7
11	5	4	14
8	10	15	1

thus providing 8 solutions from Key-Table I., while Key-Tables II. and III. each yield a similar number, giving a grand total of 24. Similarly for any of the first sixteen numbers selected.

Mention has been made above of the "graphs" of these squares, and I will therefore only remark here that some of them produce very pretty patterns. As an example I give a square, derived from Key-Table I., with its graph.

1	15	10	8
12	6	3	13
7	9	16	2
14	4	5	11



I should have mentioned that the term "Nasik" is now generally applied to such squares.

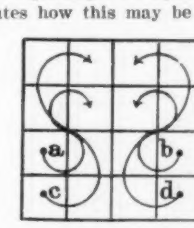
Allusion is sometimes made to the following magic square:

16	3	2	13
5	10	11	8
9	6	7	12
4	15	14	1

which appears on a 16-paned window in the background of Albrecht Dürer's picture "Melencolia." The date of the picture is recorded as 1514 in the left-hand bottom corner under the initials "A. D."

Now, while the square is not a supermagic square, it possesses the peculiarity that the two centre numbers on the lowest line form a chronogram of the date.

The square is readily derivable from the Dudhai square, reproduced at the head of this article, or indeed from any supermagic 34 square. The following diagram indicates how this may be effected.



It remains only to notice that, while the Dudhai square was so placed as to be beyond the ken of the vulgar, Dürer's bastard version of it appears in the midst of certain emblems, and this coupled with the fact that the artist lived at Nurnberg, an architectural centre, may serve to suggest a common masonic origin for both efforts.

Molecular Orientations in Physics and in Crystallography—II*

A New Hypothesis in the Investigation of Matter

By Albert Perrier, University of Lausanne

[Concluded from Scientific American Supplement No. 2245, Page 19, January 11, 1919]

Before introducing a new hypothesis into the theory, and venturing upon more complex considerations, let us take a backward glance over the history of the development of physics in this field during the last sixty years; we shall be content to mark the principal stages of this development by four groups of phenomena which all possess the common characteristic of *temporary anisotropy provoked either by the magnetic field or by the electrical field.* And the theories invoked by their explanation contain at least one common hypothesis, namely, the incomplete and variable orientation of molecules; besides the lucidity and beauty of the explanations thus obtained we have been led to suspect by the very diversity of the applications, the richness in results, laws or experimental facts to be obtained by making use of these theories; they have also yielded numerous hints as to the nature of molecular structures. However, these stages of progress have not occurred at regular intervals. For fifty years this hypothesis had scarcely any application except to ferro-magnetism—it is hardly more than a decade since all its extensions have been found possible and fruitful, namely, since the introduction of the idea of thermic agitation, *i. e.*, the creation of kinetic theories derived from statistical mechanics. This extension, in itself, marks an important date in theoretic physics, and it also helps us to understand, by reason of the difficult mathematics involved in these theories, why the crystallographers and the physicists have remained so far apart in their estimates of a domain which is their common property.

However, to adopt my former metaphor, the fluvial basins of these two kinds of researches have been connected by a wide canal which allows their waters to mingle: I refer to the theory published by P. Weiss in 1907 concerning the *molecular field and spontaneous magnetization.*[7] Let us consider briefly these ideas, which were entirely novel and unexpected at the time they made their appearance. The origin of this theory, which is at once so bold and yet so logical, is to be found in a long series of crystallomagnetic researches by the same author, upon pyrrothine in particular, which finally led him to believe, contrary to all the facts known up to that time, that *crystalline elements which are sufficiently small cannot be magnetized except in a single degree, namely, the maximum degree, or saturation;* any other degree of magnetization is impossible, even when the influencing force is nil, and this state has been characterized by the striking term *spontaneous magnetization.* Shortly afterwards the curious ideas, thus expressed at first in a purely geometric form, found both their application and their explanation in the *theory of the molecular field* of the same physicist. This, as we know, grafts upon Langevin's kinetic theory of paramagnetism the action exerted by molecules upon each other, which he supposes to have the same effect as a magnetic field, extremely intense moreover, in proportion to the degree of magnetization attained; the result is an enormous magnetization, *spontaneous magnetization,* in fact, which cannot be perceptibly increased by any force which we know how to produce; it may, therefore, be considered to be saturation.

But this does not mean that all the molecules are parallel; there is probably an *average* equilibrium between the directing effort of the inter-molecular forces and the antagonistic effect of thermic agitation. The most immediate consequences of this theory are readily deduced: without the molecules being modified, heat must always cause spontaneous magnetization to diminish, and furthermore it must *necessarily disappear* when a certain temperature is reached; these are facts which were long ago proved to be true in the case of all ferromagnetic bodies but which had remained enigmas; Curie alone had previously lifted a corner of the veil which covered their profound origin. Hereby the extension of this theory to all the ferromagnetic bodies, and no longer merely to pyrrothine, to which the application was evident, appeared to become necessary. Furthermore, this new theory of ferromagnetism immediately proved its worth and its fecundity by suggesting a new series of experimental questions, and causing the prediction of numerous phenomena as yet mostly unsuspected. And a brilliant series of experimental researches issued therefrom which were described recently by their author at the public meeting at Altorf.[8] I will confine myself to the mention of their most striking results; namely, the variations of specific temperatures (particularly their discontinuities) the analysis of the structure of metal alloys including the ferromagnetic bodies and the discovery of new combinations in these alloys, the values of absolute saturation (at extremely low temperatures), the strange and remarkable laws in regard to what are called "initial" susceptibilities, the rationality of molecular magnetic moments and the magneton and so forth.

Since then the quantitative pursuit of the consequences of this theory have given me the first clear theoretic idea of the thermomagnetic functions in all fields whatever, and inversely, there has issued therefrom a new series of observations governed by remarkably simple laws in realms where everything has hitherto seemed obscure.[9] I will merely emphasize the fact that this harvest of the last decade is as rich in laws regarding phenomena as in information concerning molecular construction, while it comprises furthermore many results not strictly included in field magnetism (specific temperatures, alloys).

However, we must not lose sight of our main objects among these various new researches. Let us return for a moment to this physical idea which has been preponderant in all these investigations, which has been the beacon preventing investigators from wasting their time in futile efforts and which has enabled them clearly to interpret the results obtained, namely, spontaneous magnetization; but we will consider this from a less specific point of view. May we not regard a fragment of matter spontaneously magnetized simply as a body in which all the molecules are turned by preference in a single direction, and in which this orientation is natural—in which it exists in the absence of any external agent? You have all recognized herein *a concrete and verified realization of the abstract hypothesis of crystallography,* and I was justified, therefore, in my statement that this spontaneous magnetization is the first element of a union between geometric crystallography and the anisotropies of the physicists.

But how far more precise, more perfect and more profound is this new form of the hypothesis! The dissymetry represented by magnetic poles ceases to be a more or less geometrical conception—we understand it, we can measure it, we know the moment of these poles; we know, moreover, in general, how the forces which have this effect upon the molecules operate; we know furthermore, and this is an enormous step in advance, that this orientation is only an average manifestation since each molecule is in motion; finally, we have gained a number of data concerning the laws of this motion and as a result we know by what external agents the anisotropies resulting therefrom can be modified, and can predict the manner and direction of this modification. . .

Unfortunately the application of this theory seems to be very limited by the nature of things: as we have seen, the formulation of hypotheses frequently enables us to obtain by experiment richer results and to obtain them more directly, but the field of application is likewise correspondingly limited—in fact, spontaneous magnetization, which is a characteristic of ferromagnetism, is of no significance except for the very small number of crystals of iron, nickel, cobalt, etc., which possess this property. But so great has been the progress made in a very short period of time, so seducitve is this theory and so general and so indispensable, moreover, is the crystallographic idea of orientation that our minds are inevitably led to seek to extend it; . . . we ask ourselves whether other phenomena of natural anisotropies of crystalline anisotropies may likewise be explained by spontaneous orientations whose mechanism is similar to that encountered in magnetism, and we pursue the idea further by asking whether all the cases of orientation remarked by the crystallographers can be explained by a single theory coinciding in form with that of magnetism—those cases, that is to say, in which there intervene thermic agitation and its corollary, a stable average orientation, but in which the nature of the molecular dissymmetry is different as well as that of the mutual forces directing the molecule. If we find the answer to be affirmative we shall have made an enormous advance in the direction of unifying the theories of temporary anistropies and those of crystals.

I shall attempt to give some novel answers to these stimulating questions—merely partial answers and not *the* answer, for we enter here into the most recent fields of research, realms in which investigators make use of what are called "working hypotheses" without regard to the degree to which they stand the test of experiment, into realms in which the few students who have explored them are far from agreeing with each other with respect to the value of the theoretic tools which they respectively utilize.

Let us consider, in the first place, a phenomenon which at first glance is singularly remote from those which we have hitherto considered; namely, the electric current passing through a metal conductor; its modern interpretations upon the theory of electrons have assumed two different forms. The one which is alone accepted upon the continent (Drude, Lorentz, Riecke), and which is based upon the kinetic theory of gases, is of much less interest from our present point of view than the other, that of J. J. Thomson. The general idea of the latter is that the electric current consists of a continual passage of the negative electrons of molecules to their neighbors, it being assumed, however, that the molecules behave like small guns projecting their electrons only in certain directions, so that a *current* is capable of flowing in a given direction only when the molecules are oriented in that direction, the completer the orientation the greater being the intensity of the current. To comprehend Ohm's law we need only assume that each molecule has two electric poles (positive and negative) and that consequently an electric field (proceeding from the difference of potential) tends to make these little guns revolve and point in certain directions; furthermore, the thermic agitation produces a continual derangement of direction, which immediately explains the well known fact of the increase in metallic resistance corresponding to a rise in temperature; here we have a form of reasoning analagous to that employed by Langevin with respect to magnetism, but in a different field.

Without stopping to consider possible objections let us pursue a line of reasoning analogous to that stated above—let us conceive the mutual actions of the molecules upon each other sufficiently great to cause them to undergo a tremendous degree of orientation below a given degree of temperature—the conclusion which we are forced to accept is fairly staggering: namely, *that if a wire could be the seat of an electric current without any maintaining cause, without a continuous expense of energy, then its resistance would be nil!* But the fact is that this astounding result was observed even before it was foretold. All recent works on physics contain an account of the brilliant discovery by Kamerlingh Onnes of super-conductors, and it is now a known fact that certain absolutely pure metals, mercury for example, cease to exhibit any perceptible resistance to the passage of the electric current when they are cooled to a temperature within a few degrees of the absolute zero. And very recently, indeed, J. J. Thomson[10] published a quantitative study of conduction grounded upon this fact.

Of course, it is not absolutely demonstrated that things occur in just this manner, but it is precisely this uncertainty which emphasizes the fecundity and convenience of the interpretations given above, which cause facts utterly incomprehensible under any other known theory to appear entirely natural. And we also find herein a beautiful example of a common explanation of the phenomena of anisotropies whether temporary and variable or stable, since a conductor traversed by a current has a privileged direction and is an anisotropic system in the sense in which we have employed the term.

From this idea of the conductibility of matter we

*An abstract of an address given before the Helvetian Society of Natural Sciences at Zurich, Sept. 10th, 1917, and published in the Minutes of the Swiss Society of Scientific Research, 1917, vol. II.

[7] P. Weiss, Jour. de Phys. (4), VI (1907), p. 661.

[8] P. Weiss, Archives of Natural and Phys. Sciences, 1912, vol. 34, p. 98, also Minutes of Swiss Society of Scientific Research 1912, II, p. 59.

[9] Alb. Perrier, Archives, etc., 1909, vol. 28, pp. 519 to 37; id. 1913, vol. 34, p. 360 and A. Perrier, and Balachowsky, G. Archives 1916, vol. 42 p. 321.

[10] J. J. Thomson, Phil. Mag. (VI), 30 (1915), p. 192.

can pass at a single bound to the electric properties at the other extreme, to the phenomena that are exhibited by perfect insulators.

I have just given an outline of the fundamentals of the theory of the polarization of dielectrics based upon the orientation of molecules possessing electric poles; let us assume in the same way that reciprocal actions are concerned in the case of superconductors—we find ourselves confronted here with a possible result analogous to spontaneous magnetization, but electrical in this instance; we are led to conceive of the elements of matter as extending all their poles of the same kind in the same direction, of elements in a state of *electric saturation* without the agency of external forces (without being subjected to any electric influence). But this state of natural and permanent polarization will not, as easy and immediate observations might lead us to believe, be demonstrated on the ground of residual magnetization; for every body, in fact, no matter how strongly electrified and how well insulated it be, will gradually become neutralized in any case by the slow accretion of charges from the air. Only a rather rapid modification of this latent electrification is capable of causing poles to make their appearance upon the body, and only the phenomena of pyro-electricity (electricity caused by heat) and of piezo-electricity (electricity caused by pressure), which are both rare and difficult to observe, are capable of corresponding to these predictions; these may be stated as follows: Certain crystals when heated or cooled, or when compressed or expanded, that is, in general, when they undergo a change of form, react by exhibiting positive and negative electric charges, the strength of these charges being in exact proportion to the degree of the elastic deformation or of the variation in temperature.[11]

As I have just said, the possibility of interpreting these phenomena by spontaneous electrification is very alluring; in fact, any deformation, *i. e.*, a variation of molecular distances, will doubtless cause variations in the mutual forces concerned; furthermore, a change of temperature, *i. e.*, the modification of the thermic agitation always signifies a disturbance in the average directions; in both cases the consequence is a variation in the spontaneous electrification and the external manifestation of piezo or pyro-electric charges.

In developing this theory I have endeavored to discover what results would be yielded by experiment, and I have obtained from very recent researches results which are full of promise not only with respect to facts hitherto unknown, but in explanations of empirical laws whose origin had remained obscure; among these I may cite the following: A thermic variation is to be expected and in particular a temperature at which the piezo- or the pyro-electricity will entirely disappear, and this temperature has, in fact, been already observed in the case of quartz (cc. 580°C.), a phenomenon hitherto entirely unsuspected; this temperature has proved to be identical with that of the transformation of *alpha* quartz into *beta* quartz by means of expansion discovered by H. Le Chatelier. Moreover, by means of this theory, based upon the discovery of the disappearance of the piezo-electricity, the nature of this transformation from the *alpha* to the *beta* form seems to be revealed as the electric analogue of the change of *alpha* iron into *beta* iron by Curie's point. Furthermore, such a transformation interpreted in this manner should be accompanied by a considerable diminution in the internal energy of the matter, in other words, by *anomalies of specific temperatures*. . . . Certain measurements which are still rather summary have verified absolutely this fact which had always been foretold with regard to quartz—and even the most characteristic optical properties of the crystalline state, double refraction and rotary polarization, seem to exhibit a very definite relation with our hypothetical structure; consequently, it is my opinion that this throws new light upon the extremely complex question of the thermic variation of these optical phenomena.[12]

Shall we seek still further extensions? All those which we have attempted to find concern either the natural anisotropies of crystals or those of naturally isotropies of crystals or those of naturally isotropic liquid or solid matter, which is, however, capable of appearing anisotropic under the temporary action of magnetic or electrical fields; two special states of matter which belong on the whole to neither of these classes will perhaps permit us to make similar extensions, namely, *liquid crystals* and *capillary layers*. Here we enter more and more into the domain of hypotheses which must be regarded merely as possible.

The liquid crystals of Lehmann, those microscopic systems which are liquid in their consistency but which are very markedly dissymmetrical in their optical and even in their magnetic properties, have given rise to a number of theories, and orientations have naturally been invoked also though without greater precision. To my mind we can here, better than elsewhere, make use of this theory of spontaneous orientations which are very much accentuated by reason of the probable absence of the network, properly so-called. This is undoubtedly a highly interesting field of investigation, and the remarkable results obtained by Mauguin seem to support this hope.

Finally, what can we expect to discover in the consideration of that extremely thin area of the liquid which lies next to its free surface and which we call the capillary layer? In my opinion this is a very fertile field, so much so that its study in the light of recent ideas will undoubtedly alter the whole theory of fluids. Proofs of this are to be found in the recent researches of Lenard[13] regarding this phenomenon, which is to all appearance so remote from the disengagement of electricity by the pulverization of liquids (*Wasserfallelektrizitact*). In Lenard's opinion the free surface is a double layer of positive and negative electricity, and this peculiarity can be explained by the perpendicular position of all the molecules adjoining the surface causing them to present all their electrical poles of the same kind towards the exterior, like the quills upon a porcupine. But whence does this orientation proceed? From the forces exerted by the molecules upon each other, whose existence is well established and which are evidently normal to the free surface in its vicinity. And by this assumption, let us note, we are brought back quite unexpectedly, in the midst of the theory of isotropic phenomena, at once to the compressibility of fluids, for the forces which I have just mentioned are none other than those which Van der Waals utilized in his celebrated synthesis of the ensemble of the phenomena of the variability in the volume of gases and liquids, which led him to discover the explanations of the continuity of the liquid and the gaseous states. Hereby we are led to consider these forces as being electrical, and many new views with regard to cohesion and molecules are already being formulated as a consequence of this conception; the Dutch physicist, W. H. Keesom,[14] in particular, has already shown the fecundity of this view independently of Lenard, and in an entirely different direction, by perfecting the equation of the state of fluids by the aid of electrical molecular forces. . . .

Have we not travelled a long way from the first hypotheses of Weber? We find ourselves deep in the problems that touch at bottom upon the problem of crystalline structure, *i. e.*, in fact of the structure of all solid matter, but also upon liquids and gases as well as upon aberrant states, liquid crystals and capillary layers, and also, in a general way, upon the constitution of molecules and of atoms. Our attention is engaged by problems in the solution of which every domain of physics is called upon to contribute—thermic, electrical, magnetic, optical, magneto-optical and electro-optical.

Can we go further still, will the same passport enable us to cross other thresholds? I believe so, but no one can as yet affirm it; we must not forget that the facts which I have just reviewed do not necessarily enter into the frame to which I have attempted to adapt them. I propose to myself to lead you as far as it is possible to go at present, but in proportion as we have travelled further from the first phenomena of ferromagnetism, to explain which the hypothesis was created, the adaptation becomes more arbitrary and frequently more difficult; we must remember, in order not to be over bold, the history of the theories formulated by Fresnel to explain luminous phenomena, which in spite of their admirable harmony and their unsurpassable lucidity finally had to be renounced in the course of the unceasing series of discoveries made by experiment.

In spite of all, however, I will formulate two questions which will act as landmarks: Is it possible that we shall be able to utilize the orientations of ions or of atoms to explain the problem of the forces which cause chemical affinity? Shall we be able some day by the help of the peculiar positions of molecules, either natural or forced, to penetrate the mystery, as yet almost unsounded, of the forces of cohesion in solid matter, or those which maintain the structure of crystalline forms? And shall we be able even to construct a magnetic or electrical theory of elasticity? There is nothing to prevent us from thinking so, a tentative effort in this direction having been already made by Schroedinger[15]; furthermore, what we have already observed in regard to capillarity might suggest it, and a recent note, published by Deybe and Scherer[16] is also suggesitve in this respect, and finally, certain experiments made in my own laboratory will shortly, I hope, yield useful information upon the subject. And these are not the only paths which open before us. But we will go no further at this time. After this stolen glance into an uncertain future let us rather take a rapid survey of the road over which we have come.

The point of departure in its most general acceptation is a hypothesis which is primarily purely geometric: we believe in the existence of objects which are capable of revolving in such a way that their respective positions become more or less parallel to a given direction, and that the ensemble of these objects manifests special properties in that direction; but to obtain this result it is indispensable to accept also the view that each of the objects (which generally coincide with what we call molecules) possesses a dissymmetry in its own structure. In defining the physical nature of this dissymmetry we pass beyond geometry and determine by what sort of phenomena the ensemble, that is the whole body, will exhibit anisotropy. And hereby we derive the possibility of applying the same general basis in the most diverse domains.

With this same point of departure we were able to find in the midst of the variety of phenomena the laws governing similar variations. This is especially true of the effect of the variations of temperature, all cases of which the theory explains by grafting upon the hypothesis of orientability that of thermic agitation governed by the laws of statistical mechanics, or the more recent one of the quanta theory. This constitutes a second stage. By introducing, in the third place, the hypothesis of intermolecular forces into the preceding theory, we are led to the conception of spontaneous polarization fecund in magnetism, but it has led quite recently to definite but as yet isolated successes in electricity and in optics, and which are, perhaps, destined to penetrate the whole realm of crystallography. By observing that these theories constitute a primary interpretation of accidental anisotropies and of natural anisotropies by means of the same mechanism, and in particular that they contribute to bring the phenomena of crystalline optics into the electro-magnetic theory, we can form some idea of the very great interest which attaches to them in the domain of natural philosophy.

And, as we have seen, there is a very considerable number of phenomena for which this theory affords an explanation, and these phenomena are encountered throughout an area which is already very extensive and which is daily being enlarged—already including liquid crystals, superconductors, capillary layers, and so forth. But from quite another point of view our theoretic instrument has brought rich gifts to that aspect of physics which responds most completely to the curiosity of the human mind, namely, the nature of the constitution of matter and of its smallest elements: I will content myself with enumerating the valuable data in this field which have already been obtained or will undoubtedly be very shortly obtained—namely, molecular magnetic moments together with their consequence the magneton, the bonds which unite atoms, their oscillations or their rotations, their electric charges, the play of forces between molecules.

And we have not even touched upon the territory of technical applications. But this is not for lack of material! and neither have we discussed, since the matter is so obvious, the reciprocal enrichment which physicists and crystallographers may extract from a closer contact than they have heretofore possessed; they are undoubtedly destined to come into as close a relationship as that which exists between physicists and chemists in the domain of physical chemistry.

Finally, it will be of the highest interest to endeavor to derive abstract ideas from the special facts, images and theories we have considered, which are well defined but limited in their application. All of these

[11]I have described these phenomena briefly by making use of an experiment in piezo-electricity which considerably facilitates the exposition of the subject for a large audience having no special knowledge of the subject, if it is carefully performed, in the following manner: a block of polished quartz is compressed in a small screw press; we then project side by side (upon the same screen) the image of the entire press placed between two Nicol prisms and that of a small electroscope with a sufficiently sensitive leaf connected with an armature of quartz. It is evident that any deformation will be shown upon the screen by the effects of interference and by the electrical reaction at the same time: thus the exciting cause and the anisotropic reactions of the matter become directly and simultaneously visible.

[12]Alb. Perrier, Swiss Society of Physics, Berne, 1916; Arch. 1916, vol. 41, p. 493.

[13]P. Lenard, Ann. der Phys. (4), 47 (1915), p. 463.

[14]W. H. Keesom, Leyden Communications, Sup. to vol. VII, nos. 24b, 25, 26 (1912).

[15]Schroedinger, Wien Ber. (Vienna Reports) IIa, 121 (1912), p. 1937.

[16]Debye and Scherer, Phys. Zeit. (Journal of Physics) 18 (1917), p. 290.

form an ensemble so vast, and the amount of data acquired is so rich, that we might well ask if the various students in this realm have not been guided more or less consciously by some profounder and more general law, by some one of those laws which at first our intelligence does not succeed in perceiving beneath the confusing diversity of nature, but which, little by little, we come to have a presentiment of and to which, finally, the brain of some genius gives the clear and definite form which places it among those pillars which support the foundations of science and which we call basic principles.

Yet I may say, indeed, that this suspected principle was formulated years ago. When we read the first part of the works of Pierre Curie* with its wonderful observations upon symmetries which his later brilliant discoveries concerning radio-activity almost caused physicists to forget, we find there a simple phrase which constitutes the final resumé of many other beautiful laws: namely, *it is dissymmetry which produces the phenomenon*, a phrase which expresses the fact that a phenomenon possesses at least all the elements of symmetry comprised in its causes, and at most all their dissymmetries, and that it is, in the last analysis, an expression of the principle of cause and effect.

At first glance we are scarcely able to comprehend the full import of these words, but as we are here concerned with a fundamental principle of natural philosophy, we should no longer be surprised by anything in the inexhaustible fecundity of the researches which have as their object dissymmetries under all their forms. What is the tendency, indeed, of all the investigations which I have endeavored to sketch for you? It is to give privileged directions to matter and to reveal those which, though pre-existent, were concealed—in a word to bring into play the dissymmetries of nature.

It is dissymmetry which produces the phenomena, says Pierre Curie, and his words loftily dominate all our molecular theories regarding the phenomena of direction, in the same way that the second principle of thermo-dynamics, that of the degradation of energy, dominates, among others, all molecular theories regarding the isotropic properties of gaseous, liquid or solid matter. And in the light of this principle, perhaps, all our theoretic and experimental studies may appear to you as scientific confirmations of that rule of practical life to the effect that disorder hides things, and that the greater the order the more easily we find the things we are seeking; all our efforts, I will say, tend to bring order into the realm of matter to the end that we may therein discern the marvellous harmonies which nature seems, at times, to conceal with so jealous a care.

*Pierre Curie, Works published by the French Society of Physics, Paris, 1908.

Sphagnum Moss

MANY of the processes and medicaments in use by physicians have been borrowed from a non-medical source. Perhaps for generations the knowledge of their use has been handed down from mother to daughter, or from father to son. Meantime the profession has looked upon these "grandmother's remedies" with scorn, or at least with indifference, until some physician who was not too wise to learn from his lay friends has made a "discovery" which he duly reported to his medical society, or described it in a Medical Journal, and it became the common property of the profession.

A notable example is the discovery of vaccination by Jenner. The country folk were well aware of the fact that persons who, as a result of milking cows with sore udders, contracted cow-pox, were immune to smallpox. But it took a Jenner to force this idea of the protective influence of cowpox into the minds of a rather reluctant profession.

A "grandmother's remedy" more recently adopted by the profession is the use of sphagnum moss as a surgical dressing. History does not record how far back "bog moss" has been in use by the country people as a dressing for boils and discharging wounds. Perhaps some physicians were aware of this practice, but if so, they did not realize their opportunity, and passed it by as unworthy of their notice.

But back in the seventies of the last century a circumstance brought the virtues of this moss to the attention of a surgeon who did not let slip the opportunity to enrich medical practice. A laborer in a peat moor in northern Germany was seriously wounded in the forearm. Not having surgical dressings at hand his companions applied "first aid" in the form of "peat moss" picked up from the ground. Surgical help could not be obtained for ten days. Meantime the dressings were not changed. When finally the surgeon undid the wound, he was astonished to find it practically healed. Not being of the hidebound variety, he communicated his findings to his fellow physicians, and further investigation showed the great superiority of Sphagnum moss as a dressing for discharging wounds. It then became a standard dressing in hospital and private practice. In the Russo-Japanese war, the Japanese physicians used it extensively as a first-aid dressing at the front, and sometimes these dressings were not removed for as much as ten days, and yet the wounds were generally found to be in much better condition than similar wounds dressed with cotton.

There are several points in which Sphagnum moss is superior as a dressing to absorbent cotton. It will absorb liquid more rapidly, and will take up about three times as much liquid as cotton, and will retain it better than cotton. The liquid absorbed by Sphagnum distributes equally through the dressing, thus the moss continues to absorb fluid until it is completely saturated. A cotton pad will not do this.

In ordinary hospital practice where the surgeon has the time and the material to dress his wounds from time to time cotton answers well every purpose; but where wounds must be hastily dressed, to remain without further attention for an indefinite time, Sphagnum is so far superior to cotton as to be in a class by itself. The last but not by any means the least advantage of Sphagnum is that it is much cheaper than cotton. It may never entirely replace cotton in hospital and private practice, but in the emergency practice of the battle field, it is likely to be used in preference to cotton, so long as the supply lasts.—*Dr. G. H. Heald, in Sanitarium Quarterly.*

Behavior of Animals during Explosions

SOME interesting notes, which someone should collect, have been made from time to time by competent observers in regard to the behavior of various animals under the terrific conditions of noise, vibration, explosion, and other disturbances at the front. Thus it seems clear that some kinds of birds, under the dominance of instincts of feeding, nesting, or brooding, behave as if they were indifferent to the most conspicuous anomalies of their environment. Living creatures of many kinds are not in the least impressed by sounds which have no interest for them. Just as human perceptions are affected by pre-established concepts; so the intensity of animal sensations is affected by previously established associations. To terrific disturbances, which have neither inherited nor acquired "meaning," an acutely sensitive organism may remain quite indifferent. The cuckoo's calls are not interrupted by the thunderstorm. But another point is raised by some observations which Capt. W. Neilson Jones has just sent us. These refer to the diverse ways in which sheep and cows react to dummy bombs released from an aeroplane. The cows seem entirely indifferent to the "swish" of the falling bomb, but the sheep "invariably scatter in panic." The first question is whether this can be taken as a well-established fact, and the answer must take the form of a considerable number of precisely and impartially observed cases. Supposing it to be a fact, we face the second question of interpretation. Have the cows a different—more placid—temperament? But how excited they get at times by the buzzing of flies that cannot hurt them. The excitement is probably due to fallacious association with the buzzing of blood-sucking flies which can hurt them; and Capt. Jones's suggestion is that sheep are panic-struck because the swish of a falling bomb is probably not unlike the sound of a bird of prey, say a golden eagle, swooping upon the lambs. Susceptibilities of ancient origin may prove very persistent, as Mr. Robinson has so well shown in his suggestive book, "Wild Traits in Tame Animals."—*Nature.*

Linen Plant Tags

LINEN cloth is now being used to some extent for tagging plants. Writing on wooden tags soon becomes illegible, while copper tags are not only expensive, but are not large enough for sufficient data. The linen tags are first soaked several days in water to remove the sizings and then dried and smoothed with a hot flatiron. Data are written with India ink, using a round-pointed pen. The ink soaks in but does not run. Such tags will last a year or longer. When they are to be used for longer periods or under conditions where the tags come in contact with the ground, they are coated with paraffin after labeling. One method is to dip them in a mixture of gasoline and paraffin (proportion, 1 quart of gasoline to one-half pound paraffin). The gasoline evaporates, leaving a film of paraffin. If the tags become coated with mud, they can easily be washed and the ink shows up clearly. Such tags may be used in a variety of ways, for when treated in this manner they last exceptionally well.—*Jour. N. Y. Botanical Garden.*

Spectroscopy and Dissociation

IN the ordinary wind furnace, using oxygen and coal gas with a temperature 1 800-2000°, the application of a consideration of the spectra involved causes the observation that, whereas potassium and alumina give their spectra at this temperature, there is very little evidence of dissociation of silica as evidenced from the flame at the orifice. The silicon spectrum which can be obtained at the opening between the lid and body of the furnace is not one of dissociation, and evidence that the affinity of potassium and aluminium for oxygen and the corresponding dissociation is very different from the nature of combination in silica which apparently, not showing great affinity of its elements, is very difficult to dissociate. —*J. C. Thomlinson, B.Sc., in Chem. News.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

Published by Scientific American Publishing Co.
New York, Saturday, January 18, 1919

Munn & Co., 233 Broadway, New York

Charles Allen Munn, President; Orson D. Munn, Treasurer
Allan C. Hoffman, Secretary, all at 233 Broadway

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 5.00
The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Scientific American Publishing Co.
233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Table of Contents